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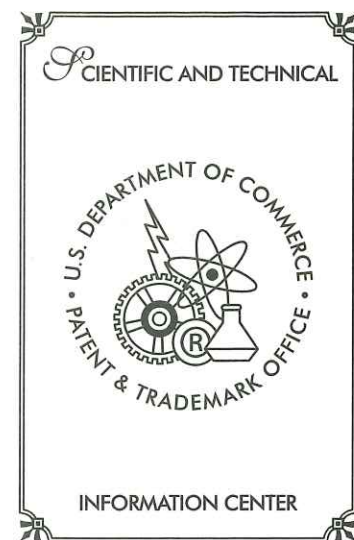


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THE PROSPECTOR'S HANDBOOK

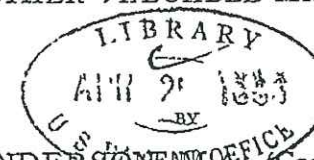
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THE  
PROSPECTOR'S HANDBOOK

*A GUIDE FOR THE PROSPECTOR AND  
TRAVELLER IN SEARCH OF METAL-BEARING  
OR OTHER VALUABLE MINERALS*



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AUTHOR OF "FIJI AND NEW CALEDONIA"



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THE  
PROSPECTOR'S HANDBOOK.



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## PREFACE.

To the lover of natural history, no matter in whatever part of the world he may travel, each tract of country offers him object after object, subject after subject, of interest. He reads sermons in stones and rocks wherever fate happens to direct his footsteps; and, if he wanders over the bypaths of untrodden ground, derives a pleasure and satisfaction from the wonderful works of nature, such as no one who has not been privileged to experience it can realise.

Geological formations, strange to the eye accustomed, perhaps, to some particular locality, continually attract his attention; while each river-bed, each mountain-side, and each precipice merits an inspection, if not a close examination.

Accompanied by very many hardships and dangers though the life of a prospector must necessarily be, it doubtless possesses an intrinsic fascination; and the fact that the prospector rarely quits his vocation for any other, when once seasoned to it, testifies in some measure to this.

Certainly there must be some extraordinary charm about his free-and-easy manner of living, and if the so-called comforts enjoyed by the majority of his fellow-countrymen are denied him, he constantly, during his arduous and hazardous explorations, is buoyed up with the pleasing hope of some day in the future, he knows not how soon or how late, being fortunate enough to reap a reward for his plodding labour, or, using his own phraseology, to "strike something rich."

After traversing the mineral fields of New Zealand, New Caledonia, New Mexico, and Colorado, I feel fully convinced that some simple guide or handbook for the use of prospectors as well as travellers is a desideratum. The ordinary miner or prospector discards a lengthy descriptive work on Mineralogy, containing an account of all the known minerals, the majority of which are perfectly useless to him in his struggle for existence; and again, elaborate means of dealing with his specimens appear only like a puzzle. It is for this reason that I have endeavoured to treat the subject in as brief, though as comprehensive, a manner as possible; and, while regretting that I cannot simplify it still more, I yet hope that these pages will satisfy the requirements of at least some of those toilers who explore the trodden or untrodden tracks on the face of the globe.

I cannot conclude these prefatory remarks without acknowledging with gratitude my indebtedness to many valuable works to which, by the kind permission of the author or the publisher, I have had access. Among these I would especially mention Mr. Robert Hunt's great work "British Mining;" Mr. D. C. Davies's two comprehensive treatises, entitled respectively "Metalliferous Minerals and Mining" and "Earthy Minerals;" and Lieut.-Col. Ross recently published work, "The Blowpipe in Chemistry, Mineralogy, and Geology." I have also had the privilege of borrowing certain illustrations from these and other works, which I feel sure have greatly added to the value and usefulness of my pages.

J. W. A.

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THE  
PROSPECTOR'S HANDBOOK.

CHAPTER I.

PROSPECTING.

Prospecting for valuable minerals.—In alluvial deposits.—In veins or deposits other than alluvial.—Age of lodes.—Shoding.—Detached portions of a lode.—Proving continuity of a lode.—Vicissitudes of mining.—Necessity for a proper assay.—The value of a lode dependent on several circumstances.

In prospecting a country for mineral wealth, it is most important to search very systematically and carefully among the sands and rocks of river beds, in dry creeks, and at the bottom of valleys, as well as on the sea-shore. Not only does the action of running water and glaciers grind down masses and particles, and, through the never-changing law of gravity, deposit the debris on the lower ground; but also, as on the shores of California, Oregon, New Zealand, and elsewhere, the tides of the ocean distribute the disintegrated heavy metals in a regular fashion. The prospector should observe the characteristics of loose rocks found in ravines or gulches, more especially in eddies or dry waterholes where heavy matter is left during freshets, such as are of frequent occurrence in mountainous districts; for the holes and channels and fissures in the solid rock over which a stream runs, or has run, are frequently well worth examining. All earthy deposits being the result of either chemical or mechanical action, they usually serve as a guide to the nature of the constituent parts of the earth's crust in the immediate neighbourhood.

Prospecting for heavy metals left in the form of a deposit is based on one and the same rules, and, consequently, the search for the precious metal gold may be selected as an



exemplification of the method. In searching the sands washed down by rivers, it is well to bear in mind that if the bed of a river flowing through an open country yields fine gold dust, it will probably yield larger dust or grains nearer the mountains from which the stream runs, and grains of gold far along the stream may suggest nuggets nearer the source; because the water which has washed the gold-bearing matter from the lodes in the mountains has washed it, so to speak, down an inclined plane, leaving in its course the heavy particles and transporting the lighter farther away. The richest deposits are often those where the current has been broken by a change of descent or direction, and where a turning is abrupt, so that on one side of the stream is a cliff and on the other a gentle slope: the latter may be very rich in heavy metals. Sometimes there are several of these bends with slopes opposite cliffs, and in these slopes there is more chance of discovering gold than in places where the course of the stream is a straight one. The termination of a mountain chain, too, offers a likely site for alluvial diggings. Very commonly in a canon or gulch, where gold grains are found deposited in the lowest parts along which the river or creek runs, an accumulation of boulders or gravel may be noticed higher up the sides of the range, and more or less parallel to the bed of the creek. Portions of such deposits should be carefully examined by the eye (and by the magnifying glass), and by washing in a basin at the nearest water (as hereafter explained—GOLD, Chapter V.), as the gold-bearing matter, whether carried there in a past age by running water or glacier, may contain rich gold layers close to the "bed-rock" on which the debris rests. Should there be several distinct deposits, the deepest layer of each period is generally the most lucrative. When alluvial ground is made up of rather loose gravel mixed with boulders or lumps of rock, the gold along with other heavy substances will be found underneath the bulk of the coarse deposit, and either remains near to or on the "bed-rock," or mixed with clay; so that the earthy matter just over the "bed-rock" ought to claim much more attention than that elsewhere.

... If the clay is likely to contain the precious metal, it ought

to be washed very carefully. In prospecting a stream, should the flow of water hinder digging operations, the course of the stream must be diverted by means of back trenches, cut so that the water may flow through them; in this manner the bed may be laid bare, and then the large rocks or boulders can be easily removed and the finer gravel thoroughly washed by running water. It is advisable to remember that when gold in alluvial ground occurs, the chances are that auriferous lodes—not necessarily payable to work, yet, perhaps, of a far more permanent source of wealth than the gravels will prove—traverse the neighbouring elevations of land, and consequently the country round about should be searched for veins.

In the search for mineral veins or deposits other than alluvial, it is not advisable for a prospector to trouble himself about the comparatively recent formations nor modern volcanic rocks; for, although certain deposits do occur in the former, and rich auriferous deposits have been worked in Australia and California under formations capped by the latter, it is well to bear in mind that, excepting certain deposits of iron and also copper ore, and, of course, surface diggings, the metal-bearing mineral treasures of the earth are mined in the rocks of an older date than those of the Coal measures.

Without entering into a discussion concerning the formation and origin of veins, about which so much speculation has been rife and so many theories propounded, it suffices to say that certain laws applying to veins in one district apply also, more or less, to those in another. For instance, in any particular district the mineral-bearing lodes generally follow the same direction, that is to say their planes have the same compass-bearing, and consequently are parallel, notwithstanding a considerable distance may separate one lode from the next nearest to it. In some mining districts, a second series of veins runs at right angles to the first and principal; these lodes, however, are either of a different nature of mineral to that of the first, or if of the same, poorer in quality. It is well to recollect that a true mineral vein, where it exists, is not likely to be isolated; it rather represents, in a poorer or richer degree, many more within

reach, and which constitute a "mineral belt." For this reason, the explorer should not set his affections too much on any one "claim" until he has to his own satisfaction, if means and time allow, considered the whole district with its numerous lodes as a mineral-bearing one.

In the search for mineral veins, the prospector should study the general geological features of the country, the sections of road cuttings, landslips, precipitous cliffs, the sides of valleys, the sections of banks exposed to view (by the action of water or other denuding agency), riverbeds, dry channels, and gorges. If he find "likely" stones in a creek or valley, he should travel up it until he notices that similarly constituted stones cease to be seen, and then start up the hill-side to discover the parent rock from which they became detached. Very frequently, while at the base of a hill or mountain, there is a deposit in the form of soil washed down from the more elevated ground, higher up there is "drift" in the form of boulders and detritus, intervening between the surface and the original bedrock, and thus obscuring the solid rock formation from view.

However, by taking note of the various undulations and avoiding such places where common sense suggests that "drift" would naturally accumulate, the prospector may come across "outcrops," especially in the steep sides of gulleys and backbones of ridges; and, failing this, he may, by travelling towards the summit of any range of hills, be sure, as he approaches the top, to find less "drift" to thwart his investigations. At the same time, though he ought not to be too eager to commence work with his prospecting pick in "drift" of great thickness—say ten or twenty feet—he must, for all that, carefully notice the various "float" stones on the surface of the hill-sides, as by doing so he can often trace the rim of a particular lode hidden from view, and, if no "outcrop" of the same kind of rock has attracted his attention by leaving traces in the form of detached pieces scattered about the slopes according to the law of gravity, which distributes the pieces as they have been hurled or washed down from the parent rock with a certain amount of regularity—the larger and least weather-

beaten ones being nearest the lode—he can leastways observe at what point up the slope the "float" rock ceases to be seen; then he may sink a ten-feet-deep pit, or else drive a crosscut to strike the "body" of that which he is in search of.

Before commencing this, he must take note of the slope on which the "likely" broken away rocks repose, because judgment may tell him that the parent rock is not directly under his feet, but rather to the right or left, according to the amount of inclination of the hill-side. Much unnecessary labour is often performed through not taking account of this, as one naturally imagines that the lode is just underneath the line where the greatest amount of "float" occurs, whereas it may in reality be several yards distant, probably on the ridge just a little way off, but decidedly *not* on the other side of it.

In examining the loose rocks on the surface, the expert explorer can often form a tolerably correct notion of the nature of an underground lode, despite the fact that exposure to weather entirely alters a piece of rock which once upon a time may have been metallic in appearance before it became disconnected from its original position. So, in scaling the heights, he casts his glance in every direction, to observe if the "country rock" be "kindly" for veins, and all the while keeps a sharp look out for that kind of rock known to form the matrix of a mineral vein. The matrices are chiefly quartz, fluor spar, and calc spar; generally quartz. (See Chap. VII.)

Fluor spar (fluates of lime) is favourable for lead and copper, calc spar for lead and silver; but quartz is very nearly the universal matrix of veins in a mineral country, and thus it is that quartz rock should be especially searched for. Very frequently the pieces of quartz broken away from the lode and also the surface portion of the lode are honey-combed. Having been exposed to the influence of the atmosphere and moisture, most of the metalliferous parts once existing in the cavities, and similar to what one might expect to find a few fathoms downwards on the vein, have been decomposed, and so, instead of filling up the honey-comb cavities of the surface quartz, have merely left traces



in the form of stains. This only applies to the metallic portions oxidisable, for it is in the surface of honeycombed auriferous rock that the unmistakable yellow specks may be seen in the cells once filled up with iron or copper pyrites or other metallic compound associated with the precious metal. Gold and silver in the native state (the former very much more so than the latter, which becomes tarnished) weather the effects of the elements much better than most metals, and can be recognised in the native condition; but experience alone can acquaint one with the variously shaded greys and browns and purples which the sulphides of copper, iron, lead, zinc, &c., have left behind them as a guide. One of the best surface indications is the honeycombed rock brown with iron oxide. In the German mining districts there is a saying—

"Es thut kein gang so gut  
Er hat einen eiseren hut."

("There is no lode so good as the one which has an iron hat.") And this quite corresponds with the French "*chapeau de fer*," and the Cornish "*gossan*."

The iron oxide is really the result of the decomposition of iron pyrites; and in the lode with this at "grass roots," iron pyrites would be found deeper down. Having thus traced the honeycombed quartz—the pieces of which are less angular and smoother the farther away they lie from the lode—or other likely matrix rocks up the hill or mountain side to some outcropping rock (often forming a distinct ridge) from which it has been hurled down, or to where the detached pieces cease to be noticed, the prospector may dig a trench at right angles, if possible, to the lode in order to examine its character, the nature of the vein and the gangue, and to find the bounding walls, viz. the upper or hanging wall, and the lower or foot-wall, as well as to note the direction or "strike" of the lode; he must notwithstanding, for the sake of accuracy, "sink" a "prospecting shaft" a few feet deeper than the bottom of the trench, as the inclination of the lode near the surface is most misleading, on account of the body of ore having been distorted from its original shape. When once the probable direction

of the lode is ascertained, the positions where it is desirable that other pits, lower down or higher up the hill or on the other side of a valley, should be sunk so as to test the continuity of the vein, are settled. Should the prospect of the vein being a continuous one seem favourable, and the surface "assays" turn out well, development of the claim may be attended to.

At the same time, no person should be led away by such a hope as that "the deeper the vein the more payable the ore;" for, as a fact, though certain lead and copper veins do improve by depth, and also very many gold-bearing lodes—for instance those in Grass Valley, California, which seem to be as rich at 1,000 feet deep as at the surface—very many do deteriorate in value; nor is it prudent to attach too much affection on any particular lode, until the surrounding country has in some measure been examined. Besides, it is now a recognised fact that veins vary in quality and nature according to the strata they pass through.

Even if the prospects look bright, a person who goes in for mining ought not to be too sanguine of success, for mineral veins are most apt to disappoint; frequently do they "pinch out" between hard rocks, or end in a "pocket," or become changed in character and value when least expected. To err on the safe side, it is just as well for a happy possessor to make sure that at least the surface rock "assays" payably, simply because his money and time are of too much worth to admit of the expensive and sometimes apparently endless labour involved in developing work. A capitalist may risk some of his quickly amassed gains in following up research in the hope of some day increasing his capital, although he quite understands how thoroughly the game is a chance one; but the ordinary miner should avoid uncertainties much more than he usually does.

That a lode carries gold and silver or any other valuable metal in some form or other, is not sufficient data to lean upon in the estimation of its worth. Oftentimes the gold, for instance, is distributed in the form of very fine powder invisible to the eye and covered with a rusty film (due to sulphides or arsenides, and sometimes, as in New Zealand, to sulphate of copper and iron); and in consequence,

though the "assay" may be favourable, the extraction of the precious metal from the ore by the amalgamation is not satisfactory, as the mercury "sickens" or "flours." Again, the value of a body of ore, though it may be rich in precious or valuable metals, depends in a measure upon the nature of the other constituents, especially when the ore has to be smelted. Antimony or arsenic, in not very great quantities either, may render an otherwise valuable ore useless so far as profitable smelting is concerned. Before digging operations are commenced, the pieces of rock from the lode should be examined, and, if such is possible, by a reliable assayer, who, if he suspects the presence of precious metals, will by scorification or melting in a crucible, and afterwards by cupellation method, determine the amount of gold and silver per ton of a similar rock, and, without undertaking a careful quantitative analysis of the other associated metallic compounds, will, from the slag in the scorifier or crucible and colour or appearance of the bone ash cupel after the operation is concluded, be able to judge approximately what proportions of the metals copper, iron, lead, antimony, zinc, &c., are mixed with the others. It is always the wisest plan to obtain a proper assay before development work is entered on. Unfortunately, this is not an easy matter in out-of-the-way places. To assay correctly means a ~~course of training; for this reason the author cannot conscientiously advise any one to undertake a silver or gold assay by scorification and cupellation, nor a "burette"~~ one for copper, iron, zinc, &c., until he has practised the methods under the eye of an assayer; because in all likelihood his own attempts, though they might be near the mark as to results, would more than probably be quite misleading. Still, there is no reason why an inexperienced person should not attempt to qualitatively test minerals by simple methods, nor in some instances do so quantitatively. To fly to the assistance of a chemist or a mineralogist or an assayer for every little matter of inquiry concerning minerals is not only inconvenient, but in many mining districts unsatisfactory, as there are, naturally, so many unreliable so-called authorities to be met with. Because a miner pronounces such a mineral unlike anything he has seen in

Cornwall, or California, or Ballarat, and devoid of any valuable metal, the prospector need not be too ready in accepting such an opinion; for, as a rule, the knowledge of an ordinary miner, expert, perhaps, in certain matters, such as timbering tunnels, &c., is neither remarkably extensive nor always sound. Neither must he depend on the superficial conclusions of any professed expert who has arrived at such by a superficial examination, even with the help of a magnifying glass. Experience abroad tells one that not only has the ordinary miner erroneous notions about such minerals as grey copper ore, silver glance, fine and coarse-grained galena, &c., but also that the most experienced mineralogist cannot for a certainty tell at first sight how much gold or silver may be concealed in a particular rock. Both of these precious metals are found in such places as, for instance, New Mexico, in most unlikely formations, and it is quite a common thing to handle specimen rocks worthless in appearance and yet assaying very high in gold and silver, and also handsome looking specimens that disappoint in not "running" anything to the ton in either of the precious metals. Nor can a person, unless he be a thorough expert, depend upon the appearance of certain pieces of ore for a guide as to the yield of valuable metals. Many of the silicates, carbonates, and chlorides are perfectly unmetallic to look at, and when associated with other metals are very deceiving as to their real value. For a long time the chloride of silver deposits in Colorado were passed over without their nature being known, and so were the carbonate of lead (carrying silver) unnoticed at Leadville, which, through the discovery, in five years became a city of 30,000 inhabitants. Who would say how much per cent. of nickel there is in a particular piece of the New Caledonia hydrated silicate of nickel ore, or how much silver in the Leadville ore, or what proportion of gold is likely to be in a lump of copper pyrites or iron pyrites, unless he had made each a special study? Therefore it is just as well that a person should be independent of the opinions of others and, to a certain extent, of his own; and, at the same time, never grudge a few shillings or dollars in obtaining the advice of a proper assayer.



Let us now return to the original subject. Supposing that a correct assay of the lode matter has been secured or a rough one made, the prospector has still some items of significant worth to consider before he commences to build "castles in the air," or even continue development work. He must find out if the ground is easily worked (for in one locality though "sinking" through a soft ground may only cost £2 a fathom, "sinking" through hard ground may cost £20); if the ore to be smelted is refractory, or is capable of concentration after sorting, before it is sent away to the smelting or to the crushing and amalgamating works. He must find out exactly the price of smelting or otherwise treating the ore, taking into consideration such items as the cost of labour, the freight of ore and fluxes as well as their cost, the freight of the ores to the "works," &c. He must take into account the proximity or distance off of both fuel and water, as well as the obtainable quantity of each. Many spots in Arizona and New Mexico exist where the working of veins and alluvial diggings is impossible for the time present, or retarded through the absence of creeks and springs. He must remember that a lode running twenty dollars' worth of metals to the ton may be of more value than another running two hundred dollars not very many miles off; that a low-grade silver ore in one locality may be of more intrinsic worth than a vein of pure silver, having the thickness of a knife blade, in another.

In brief, the character and quality of ore, as well as the probability of the continuity of the lode, the location of the mining claim, the number of acres of available fuel and timber within reach, the proximity and quantity of water, every expense attendant on carriage, smelting operations, &c., should be considered in detail before the development of any single mine merits commencement, in order to turn out a profitable concern. It has been said that in the world there are ten unprofitable mines to one profitable; so let no one take the trouble to dive into the above considerations until he really believes that there is "payable stuff" to be dug out of his "claim;" let him avoid the habit of reckoning the value of a property from a few picked specimens.

## CHAPTER II.

### ROCKS.

Rocks classified.—Superposition of stratified rocks.—Lamination.—Stratification.—Denudation.—Cleavage.—Joints.—The condition under which metal-bearing deposits are found.—Nature of mineral veins in a lode, &c.—Dip.—Strike.—Clinometer.—Compass.

EVERY rock in existence belongs to one of the following main divisions:—

**IGNEOUS.** (Rocks which have been subjected to heat.)

*Volcanic* (those that have been cooled at or near the surface):—

Trachyte (rough, greyish in colour, and light in weight).

Basalt (blackish or brown, heavier, and with fewer holes in it than trachyte).

Obsidian (usually transparent and like bottle glass).

Dolerite, &c., &c.

*Plutonic* (those that have cooled at some depth below the surface):—

Felstone (of various colours, and more compact than trachyte).

Granite, porphyry, syenite, greenstone, &c.

**METAMORPHIC.** (Of igneous and aqueous origin, but which have undergone a change by pressure, &c.)

Gneiss (in composition like granite, but foliated).

Mica schists (quartz and mica).

Hornblende schists, talc schists, &c., are some of the foliated forms of metamorphic rocks.

Serpentine is supposed to belong to this class.

**AQUEOUS.** (Deposited by liquid agency.)

Gravel (made up of loose rounded pebbles).

Grit (in which the grains, usually of quartz, are cemented together).

Sandstone (in which quartz grains are very fine).

Sand (in which the grains are loose).

Clay (silicate of alumina and of a plastic nature).

Shales (hardened laminated clay).

Marl (clay containing carbonate of lime).

Loam (clay mixed with fine sand).

Flint (nearly pure silica).

Limestone, chalk, marble, &c. (made up of carbonate of lime).

Dolomite (carbonate of lime and magnesia).

With regard to the age of granite, which formerly used to be considered the oldest rock, and also that of the metamorphic rocks, the latter are of various ages and really represent certain rocks metamorphosed. It is supposed, from its nature, that granite could not have been subjected to a very great heat (although I have classed it as igneous), and though, while evidence does not deny that the basis of rock formations may be granite, still it shows that the intrusive granitic rocks which are met with in the crust of the earth belong to various ages; and it may be taken for granted that the formation of granite in another geological formation is newer than the rock which it penetrates and older than the strata deposited on it.

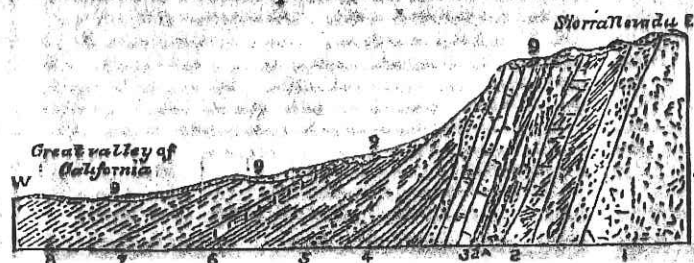


FIG. 1.—GENERAL SECTION FROM THE SIERRA NEVADA INTO CALIFORNIA

1, Granitic and gneissic rocks. 2, Slates and sandstone. 2A, Crystalline and metamorphic rocks, slates, gneiss, and gneissic rocks, in some places quartzite (gold-bearing). 3, Devonian and carboniferous limestones, with shales and sandstones (gold and silver bearing). 4, Coal measures. 5, Triassic rocks. 6, Oolitic. 7, Liassic. 8, Tertiary.

Not only are rocks deposited by the agency of water in the form of strata, but their beds also are made up of thin

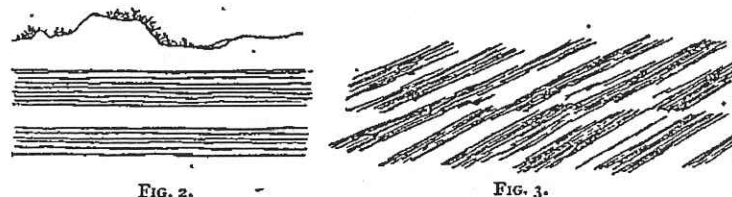


FIG. 2.

FIG. 3.

laminæ, or leaves (Fig. 2), and sometimes the laminæ lie unevenly (Fig. 3).

Stratification is by no means always horizontal, for the beds sometimes dip considerably, and sometimes have been bent by pressure or strain into curves. When the

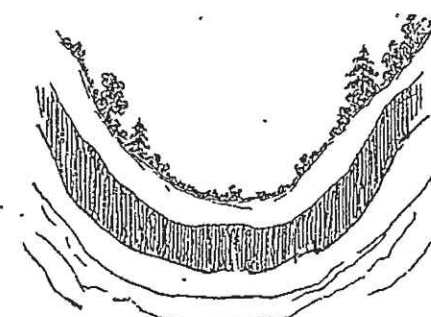


FIG. 4.—SYNCLINAL.

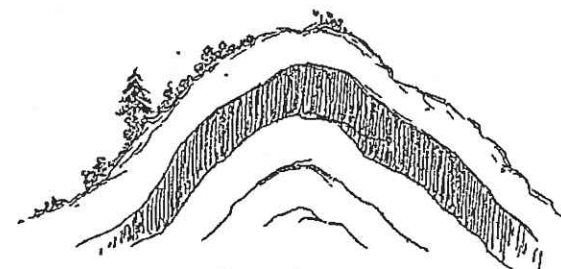


FIG. 5.—ANTICLINAL.

beds are bent into ridges or troughs for considerable lengths they are called respectively anticlinal and synclinal, as in Figs. 4 and 5.

When one series of strata is parallel to another, the two are said to be conformable; when not parallel, unconformable, as in Fig. 6.

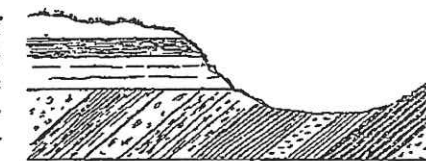


FIG. 6.

In this illustration the one set of strata (dipping 45°)

SUPERPOSITION OF STRATIFIED ROCKS.

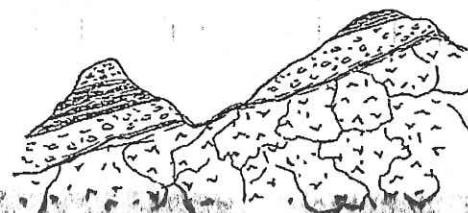
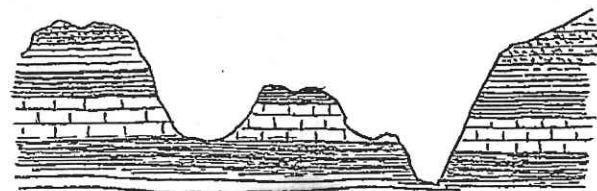
ROCK FORMATION.	COLOUR.	NATURE OF FOSSILS, &c.
RECENT & PLISTOCENE	Of many tints.	All sea-shells are of living species; bones of animals, such as bear, &c.
PLIOCENE		In England 50 per cent. of existing species of shells; bones of animals abundant.
MIOCENE	White, green, red, yellow, and other tints.	Contains about 80 per cent. of extinct shells; bones of animals; plants, &c.
Eocene		Clay, sand, &c. Contains freshwater and marine strata, extinct shells and bones of animals.
CRETACEOUS	Generally whitish.	Upper chalk and lower chalk, without flints; chalk marl; upper greensand. Contains sea-shells, sponges, sea-urchins, &c.
GAULT.	Dark blue and greenish.	Sand, clay, or marl (containing a few marine species).
LOWER GREENSAND, including WEALDEN.	Greenish, and other tints.	Clay and sand (used in glass-making). Does not contain marine species, but extensive sub-tropical flora.
OOLITE	Yellow, green, white, drab, grey, blue, &c.	Clayey and calcareous deposits.
LIAS		Clay, sand, limestone, and shales. Conspicuous for number of ammonites and nautilus shells. Building and paving stones are obtained from the Oolite and Lias.
TRIAS	Red, green, and white.	Red clays, marls, shales, and sandstones. Contains remains of fishes and reptiles and animal footprints. Contains rock-salt beds in Cheshire.

PERMIAN.	Red, yellow, white, and drab.	In England, reddish coloured sandstones and magnesian limestone. Few fossils in the former, but in the latter remains of fish with peculiar sturgeon-like tails. Animal footprints.
CARBONIFEROUS	Chiefly of a dark grey colour, with bluish or black tints.	Coal measures. Contains brands or seams of coals in limestones, sandstones, or shales; also iron ore. Freshwater and marine shells. Enormous amount of fossil plants, such as ferns, trees, club mosses, &c.
DEVONIAN	Chiefly red, with grey and yellow tints.	Milstone grit. Coarse and fine sandstone, conglomerate, and shales. Few fossils.
OLD RED SANDSTONE		Mountain limestone. Contains remains of corals, sea-lilies, and shells, &c.
SILURIAN	Grey, red, purple, green, or greenish.	Limestones, sandstones, and slates. Contains marine shell, plants, and animals.
CAMBRIAN	Various colours.	Chiefly red, though sometimes purple or green shales, limestones, and conglomerates. Contains remains of trilobites, corals, &c. This is the oldest formation in which fossil fishes are found.
LAURENTIAN	Various colours.	Clay strata, slates and shales, sandstones, grits, limestones, conglomerates, &c. Contains remains of trilobites, corals, &c. This is the oldest formation in which fossil fishes are found.
		Earthy slates, sandstones, flagstones, and conglomerates. Fossils of trilobites, &c. Roofing slates, bones and slabs, and various metallic ores are obtained from this formation.
		Crystalline gneiss with limestone beds and granite veins. In Canada it covers more than 200,000 square miles. From it are obtained building materials, &c., &c.



has been tilted up from its original horizontal position; after which the horizontal strata were deposited.

The wearing away of rocks may be produced by various denuding agents, such as wind, rain, running water, sea, frozen water, &c. Sometimes the water acts chemically and rots the rock, while rivers and rain dig and saw, the sea planes, the expansion of ice splits, and glaciers file it. As to weathering well, the sandstones seem to be less liable to disintegration than most rocks, unless they contain iron or carbonate of lime; limestones are readily attacked by water.



FIGS. 7 and 8.—DENUDATION OF STRATA.

While some rocks can be split along the layers as originally deposited, other fine-grained ones, such as slate, can be most easily so in a direction across the line of bedding. In contorted strata the lines of cleavage are parallel, as in Fig. 9. Cleavage is probably due to lateral pressure.

Most rock masses (from shrinking, in aqueous rocks; and cooling, in igneous rocks) are divided into blocks, sometimes quite regularly, by means of what are called joints. Deep in a mine, these joints fit closely; not so at the surface. Most frequently the direction is at right angles to the planes of bedding. In sandstones, the joints are irregular and the blocks of different sizes; in limestone, the joints are fewer

than in shale and some kinds of slate, and the blocks are generally cuboidal, the vertical joints being very regular.

The valuable minerals and metal-bearing deposits of the earth are found as—

*Lodes*, the ordinary fissure vein running through various strata, and the gash vein, though wide at the surface, pinching out.

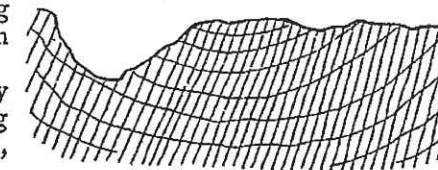


FIG. 9.

*Beds of ore*, interstratified between other beds. For instance, coal, iron ore (especially in the Oolite formation), copper ore in shale, silver and lead ore in sandstone, &c. Deposits irregularly stratified. Contact deposits between two formations where the deposit lies on the older one, &c.

*Irregular deposits*, such as pockets, &c., which lie sometimes in various formations. Contact deposits, network of veins, and where mineral is diffused through rocks, or in small cracks.

*Superficial deposits*, such as nearly all the diamond and gold alluvial diggings, stream tin deposits, &c.

With regard to the nature of the veins in lodes, the metal-bearing minerals are scattered throughout the vein stuff, or in nests and strings; sometimes they may be found next to the "hanging" and "foot" walls, or in many cases in regular symmetrical layers between layers of the different substances in the gangue, as in Fig. 10.

The angle which the plane of a stratum or lode makes with the horizon is called the dip; the line where the plane cuts the horizontal plane is called the strike. As it is of paramount importance for the geologist to thoroughly understand the full meaning of these terms, the following explanation will be of use.

If a sheet of note-paper be held so that one leaf is horizontal and the other hangs down, the angle which the latter makes with the former is the dip, and the line where the two leaves are connected is the strike. Suppose the plane of the lower leaf sloped towards the east and made an

angle of  $45^\circ$  with the horizontal leaf, it would be said to dip  $45^\circ$  E., and the strike (which is at right angles to the direction of the dip) would run north and south. The line in which a stratum or lode cuts the surface is called the "out-

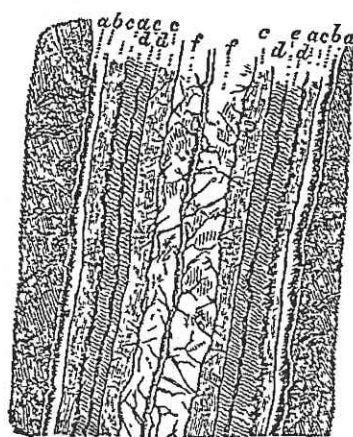


FIG. 10.—CRYSTALLIZED MINERAL LODGE.

*a a*, on each side of the lode, is a band of iron pyrites.  
*b b* represents plates of quartz upon the iron pyrites.  
*c c* are copper pyrites—the yellow sulphide of copper and iron.  
*d d* are bands of quartz and fluor spar.  
*e e* are bands of quartz containing veins of copper ore.  
*f f* are crystalline layers of quartz, with strings of copper ore.

crop," and where the surface is level the direction of course can be measured by the "strike."

In measuring the dip of a bed, or lode, or slope of a hill, the eye can be of great service in doing so approximately; but an instrument called the clinometer is of more use when accuracy is required. Various kinds of this simple instrument are to be met with, some having a prismatic compass and a spirit level in the same apparatus; the principle, however, is the same in each. A very simple one can be easily made as follows. On a rectangular piece of wood or cardboard describe a semicircle as in Fig. 11. From *c*, the centre of the whole circle, draw *c d* at right angles to *A B*. Divide *A D* into  $90^\circ$ , and *D B* into  $90^\circ$ , placing the zero mark

at *D*, and the divisions  $10^\circ$ ,  $20^\circ$ , . . .  $90^\circ$ , as in the illustration. Let a plumb-line, such as a piece of thread with a small weight at the lower end, be suspended from a nail or small pin at *c*.

Now, when the upper edge is held horizontally, the plumb-

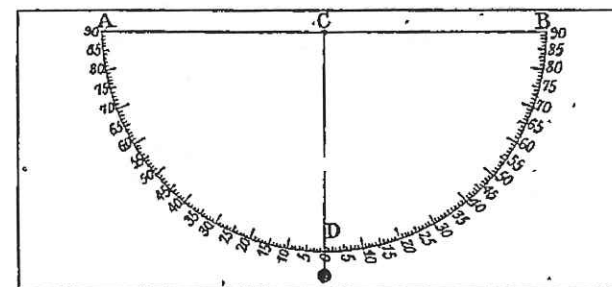


FIG. 11.

line will pass over the zero marking and hang vertically; when held parallel to the line of bedding, or lode, or slope of a

hill, the plumb-line will be inclined a certain number of degrees to the fixed line *c d*, and the number of degrees read on that point of the semicircle over which the plumb-line passes will indicate the inclination of the bed, lode, or slope of a hill to the horizon, *i.e.* the dip. A clinometer and compass may be combined in the same apparatus by fixing a small pendulum to the centre of the compass directly under the magnetic needle.

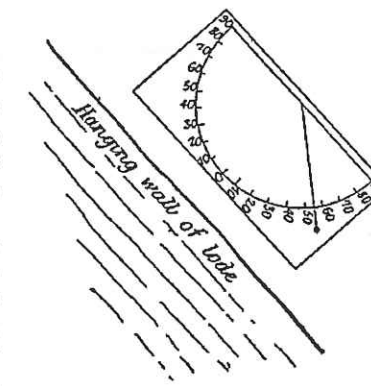


FIG. 12.—A LODGE WITH DIP OF  $55^\circ$ , AS SHOWN BY THE CLINOMETER.

To use the compass, hold it horizontally in front of the eye, and note the number of degrees which the direction of

the line looked along makes with the magnetic north as shown by the needle. The ordinary magnetic compass should be divided into degrees, so that between N. and E. are  $90^\circ$ ; E. and S.,  $90^\circ$ ; S. and W.,  $90^\circ$ ; W. and N.,  $90^\circ$ .

Suppose the observer looking along the strike of a lode notices that its direction is  $30^\circ$  from the north towards the east, the direction is said to be  $30^\circ$  E. of N. Although the prospector in his calculations will probably only note his readings from the magnetic north, it may be well to remind him that the magnetic north differs from the true north. If the latter is required at any time it can be found by noticing the shadow which a vertical post casts at noon.

### CHAPTER III.

#### TESTING MINERALS BY THE BLOWPIPE.

Apparatus required.—How to use the blowpipe.—Nature of the flames.—Methods of testing in an open tube and a tube closed at one end.—On charcoal with carbonate of soda.—With borax and microsmic salt on platinum wire.—Tables of reactions with borax and microsmic salt.—Testing with nitrate of cobalt.—General table (for the qualitative analysis of metallic substances).—Confirmatory tests.—To detect certain common substances associated with metals.

APPARATUS required consists of the following:—Blowpipe. Candle or lamp (fed with oil or melted tallow). Forceps with platinum points. Charcoal. Steel forceps. Platinum wire and foil. Magnet, or magnetic needle, or magnetic knife blade. Knife. Mortar (agate is the best material) and pestle. Borax, microsmic salt, carbonate of soda in small boxes. In addition to the above, a small bottle of hydrochloric acid, and also some nitrate of cobalt solution, will be most useful. A few small open glass tubes, and glass tubes closed at one end. Many other articles might be of great use, such as a small aluminium plate, some nitric acid, sulphuric acid, zinc for confirmatory tests, and also hyposulphite of soda; at the same time, they are not absolutely necessary.

In testing the quality of a mineral by the blowpipe, a small but well-chosen fragment about the size of a mustard-seed is sufficient.

In using the blowpipe, the principal thing to learn is to blow and breathe at the same time without removing the mouth from the instrument. This is effected by filling the mouth with air and gently blowing, and at the same time by breathing through the nostrils.

A lamp with a large wick, and fed with olive oil or melted tallow, affords a good flame, and so does an ordinary candle with a broad wick.



The blowpipe flame consists of two parts, the blue one (made up of inflammable gases) and the yellow one. The former requiring oxygen is called the "reducing" flame, and the greatest heat is at the end. To obtain the reducing point the blowpipe jet should be just over the wick of the

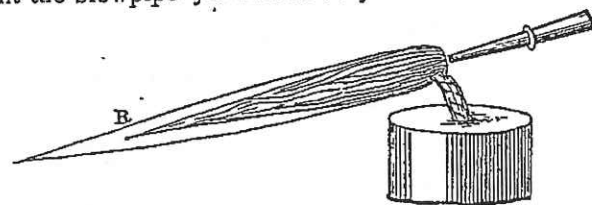


FIG. 13.—R—REDUCING POINT.

candle or lamp (Fig. 13). At the extremity of the yellow one (the whole of the gases being consumed) bodies are combined with oxygen, and this is called the "oxidizing" flame. To produce it properly, the blowpipe should be placed a

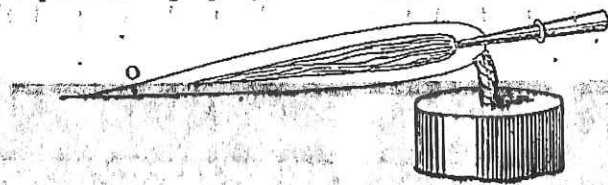


FIG. 14.—O—OXIDIZING POINT.

little farther into the flame, and the operator should blow more strongly (Fig. 14).

Treatment in a tube closed at one end (Fig. 15) is best



FIG. 15.

conducted over a spirit lamp. When the substance is to be heated in an open glass tube (Fig. 16), the tube should be inclined so as to allow a current of air to pass through. (N.B. By heating a point of a straight tube in a spirit lamp, the tube may be bent into the required angle.) The charcoal on which the mineral is to be heated ought to be made

from very light wood—such as elder, pine, &c.—and which, when heated, should be as free from smoke and ash as possible.

To treat the substance on charcoal, a small cavity should be bored on the edge of the grain in the top part of the charcoal by means of a knife-blade, and when the blowpipe flame is directed on the specimen, the support should be held in an inclined position, in order that the incrustation deposited on the cool portion can be properly noticed.

An aluminium plate about 4 inches long by 2 broad, and  $\frac{1}{8}$  inch thick, and with half an inch at the end bent nearly at right angles to the other part, and on which the specimen can be rested, is a capital support; only, as the plate is apt to become very hot during an operation, it must be held by tongs, the handles of which are wadded, so as not to come

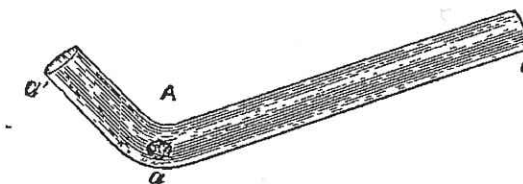


FIG. 16.

in contact with the operator. In using this support the specimen may be placed on a thin piece of charcoal. The incrustations on the aluminium plate are thicker than those on the charcoal support, and they can easily be experimented on by the blowpipe. When the operation is over, the plate may be cleaned by rubbing it with fine bone ash, by means of a piece of washleather.

Firstly, treat the substance alone on charcoal, and notice the effect of the oxidizing and then of the reducing flame on it. After which, treatment with carbonate of soda, and afterwards with borax and microsmic salt, may be necessary.

As, sometimes, metals cannot be reduced from minerals by simply heating on charcoal alone, carbonate of soda is made use of. The substance should be very finely powdered and mixed with slightly moistened carbonate of soda, then placed in the cavity of the charcoal, and a gentle heat applied

to it in order to drive off moisture; afterwards, the temperature should be considerably increased. Not only must the colour of the incrustation be noticed, but also the fused substance along with some of the charcoal ought to be removed, and ground up with a little water in an agate or porcelain mortar. More water should be added, and the whole mixed up; the water, together with the lighter matter, should be poured off very carefully; which may be done with the help of a small glass rod or pencil placed at the side of the tilted-up mortar, so as to allow the water to run gradually down the side. The residue at the bottom of the mortar is thus ready for examination, and the metallic fragments, if any, will be seen by the naked eye or a magnifying-glass as glistening spangles or as powder.

When there is no incrustation, the metals—gold, silver, and copper—if present, yield glistening beads, and iron, nickel, cobalt, leave a magnetic grey powder.

Should there be an incrustation, the General Table C must be consulted, though each of the metals—silver, tin, lead, antimony—may be recognised in the residue by its characteristic appearance. As a rule, one ought not to rely upon the treatment with carbonate of soda, rather confirm by that with borax and microsmic salt.

The useful fluxes, borax and microsmic salt, readily dissolve metallic oxides at a high temperature. In order to make sure that the substance is in the state of oxide, it should be exposed to a gentle heat and roasted, in order to drive off sulphur or arsenic associated with metals in the mineral.

To treat with either of these fluxes, bend the end of a small platinum wire round the point of a pencil into a loop of this shape and size—

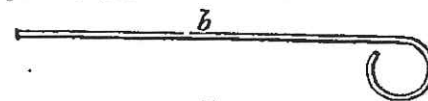


FIG. 17.

Moisten the loop, and dip it into either borax or\* micro-

\* N.B.—Microsmic salt is inclined to froth up and fall off the wire; so only a very small quantity must be taken up at once.

TABLE B.

With Borax.			With Microscopic Salt.		
In Reducing Flame.			In Oxidizing Flame.		
Bead.	Hot.	Cold.	Hot.	Cold.	Hot.
Yellowish.	Colourless.	Grey.	Colourless.	Colourless.	Grey.
Blue.	Blue.	Blue.	Blue.	Blue.	Blue.
Green.	Colourless.	Brown.	Green.	Blue.	Brownish red.
Yellow to red.	Colourless to yellow.	Bottle green.	Yellow to red.	Colourless to yellow or brown.	Colourless to red.
Yellow.	Colourless.	Grey.	Colourless.	Colourless.	Grey.
Violet.	Reddish brown.	Grey.	Reddish to brownish red.	Yellow to reddish yellow.	Yellow.
Colourless.	Colourless.	Grey.	Yellow.	Yellow.	Grey.
Colourless.	Colourless.	Colourless.	Colourless.	Colourless.	Colourless.
Yellowish.	Colourless.	Grey.	Colourless.	Colourless.	Grey.

TABLE A.

		With Borax.		Indication.		
		In Oxidizing Flame.	In Reducing Flame.			
Bead.	Hot.	Cold.	Hot.	Cold.		
Yellowish.	Colourless.	Colourless.	Grey.	Grey.	ANTIMONY OXIDE	
Blue.	Blue.	Blue.	Blue.	Blue.	COBALT	
Green.	Bluish green.	Bluish green.	Colourless.	Brown.	COPPER	
Yellow to red.	Colourless to yellow.	Colourless to yellow.	Green.	Bottle green.	IRON	
Yellow.	Colourless.	Colourless.	Grey.	Grey.	LEAD	
Violet.	Reddish brown.	Reddish brown.	Grey.	Grey.	NICKEL	
Colourless.	Colourless.	Colourless.	Grey.	Grey.	SILVER	
Colourless.	Colourless.	Colourless.	Colourless.	Colourless.	TIN	
Yellowish.	Colourless.	Colourless.	Grey.	Grey.	ZINC	

mic salt, and then heat it in the blowpipe flame till the flux is fused. When the head is soft or moist, it must be brought in contact with a very small quantity of the powdered mineral, and then exposed to the heat of the oxidizing flame, and afterwards to that of the reducing flame, the change of colour of the head when hot or cold, and the effect of each flame on it, being carefully observed.

If the substance, after heating, be moistened with nitrate of cobalt solution, and again strongly heated, it may when cool afford some clue to its nature (see Table C).

This reagent is often used for detecting—

{ manganese, which gives a fresh red colour;  
alumina, " " blue without lustre.

#### GENERAL TABLE C.

(For the Analysis of Metallic Substances.)

1. Heat the substance in a tube closed at one end:—
  - Sublimate: white = mercurous chloride, white antimony, &c.
  - " greyish black = mercury, &c.
  - " black, red on rubbing = cinnabar (sulphide of mercury).
2. In open tube:—
  - Sublimate: metallic globules = mercury.
  - " white fumes = antimony.
3. Alone on charcoal:—
  - Colour of outer flame: green = copper, &c.
  - blue = lead, chloride of copper, &c.
  - (i.) Metals reduced without incrustation:—
    - White, malleable bright bead = silver.
    - Yellow " " = gold.
    - Red metal " " = copper.
    - Grey powder = iron, cobalt, nickel, platinum.
  - (ii.) Metals reduced with incrustation:—
    - Incrustation: bluish white = antimony.
    - lemon yellow when hot } = lead.
    - sulphur yellow when cold } = tin.
    - yellowish when hot } = tin.
    - white when cold } = tin.
    - Incrustation without reduced metal:—
      - yellow when hot } = zinc.
      - white when cold } = zinc.
4. On charcoal, with carbonate of soda:—
  - Same as in '3.

5. On platinum wire with borax:—  
Consult Table A.
6. On platinum wire with microsmic salt:—  
Consult Table B.
7. Heated on platinum wire moistened with hydrochloric acid:—  
Flame colour: blue = copper, afterwards green, lead, antimony, &c.
8. On charcoal with nitrate of cobalt solution:—  
Green mass = oxides of zinc, antimony, tin, &c., &c.

Confirmatory tests when the mineral has been treated alone on charcoal or with carbonate of soda:—

(i.) When metallic heads or spangles are left:—

Silver.—If dissolved in nitric acid, an addition of hydrochloric acid or a solution of common salt will precipitate white chloride of silver.

Gold.—If dissolved in 4 parts hydrochloric acid and 1 part nitric acid a precipitate of purple of Cassius will be obtained when protochloride of tin is added.

Copper.—If treated with borax on platinum wire it will give reactions, as in Table A.

(ii.) When a grey or blackish residue is left:—

Heat the residue with borax on platinum wire and note the colour of the bead; compare results with Table A, for COBALT, COPPER, IRON, NICKEL.

(iii.) When the mineral yields an incrustation on the charcoal:—

Antimony.—If the scraped-off incrustation be treated with hydrochloric acid and zinc on a piece of platinum foil, a black film of antimony is formed.

Lead.—If dissolved in nitric acid, the excess of acid evaporated, and a little sulphuric acid be added, a white powder will be formed.

Tin.—If dissolved in hydrochloric acid, a grey precipitate is formed when metallic zinc is placed in the solution.

Zinc.—If the incrustation be heated with the nitrate of cobalt solution, it becomes green.

To detect certain common substances associated with metals:—

Alumina.—This is known by its adhering readily to the tongue when licked. Tested before the blowpipe with nitrate of cobalt, it becomes blue.



**Lime.**—This gives a very bright light when heated before the blowpipe flame. It is infusible even with carbonate of soda, and so differs from *silica* and flinty substances.

**Carbonate of Lime** effervesces when a little hydrochloric acid is dropped on it.

**Magnesia.**—When heated with nitrate of cobalt solution, becomes flesh red.

**Soda.**—When strongly heated, gives a reddish yellow colour to the outer flame.

**Potash** gives a violet colour to it.

**Sulphur** is known by its characteristic odour when the substance is roasted. If a portion of the heated mineral be placed on a moistened piece of silver, a black stain shows the presence of sulphur.

**Arsenic** is known by its characteristic garlic odour when heated.

All *carbonates* effervesce in acids. (N.B. A limestone rock, which is made up of carbonate of lime, can thus be easily distinguished from a sandstone, &c.)

*Certain silicates*, when acted on by acid and heated, gelatinize.

## CHAPTER IV.

### THE CHARACTER OF MINERALS.

External Characteristics.—Specific Gravity.—Hardness.—Crystallization.

IN order to discover the nature of a rock, the mineralogist may derive the necessary information by a careful study of its external appearance and characteristics; the form of crystallization, hardness, specific gravity, colour, streak (the colour when scratched, or when rubbed on a piece of porcelain), &c., and also from its behaviour when exposed to the action of chemicals or heat.

To find out the composition or nature of a mineral by its colour and external qualities is an art acquired only by practice; at the same time, a few such hints as the following may be useful.

A white soft mineral might be—

Clay (which adheres to the tongue).

Chalk (which is white when heated).

A white hard mineral might be a hard clay or argillaceous iron ore or metallic oxide, carbonate, &c.

A yellow mineral might probably be an oxide (hydrated) of iron, &c.

If yellow, hard, and crystalline, a mineral might probably be a sulphide.

If red, a mineral might be an iron, though perhaps a mercury, lead or zinc, copper or silver ore.

If brown, probably an iron, though perhaps a mercury, lead, or zinc ore.

If black and metallic, perhaps a magnetic iron ore (attracted by the magnet), though other minerals such as graphite, &c., are blackish.

If green, silicate of magnesia, copper ore, &c.

These hints, however, are of no real worth where accuracy is desired.

The specific gravity of a rock can often be approximately known by weighing it in the hand and comparing it with an equal bulk of some other familiar rock; but to accurately obtain the specific gravity of a mineral, a fragment of it should first be weighed in air, then in water (which can be done by suspending it to the scale of a balance and immersing it in water). The weight in air, divided by the weight in air minus the weight in water, gives the specific gravity.

$$\text{S.G.} = \frac{\text{weight in air}}{\text{weight in air} - \text{weight in water}}$$

The colour and appearance of the line or furrow on the surface of a mineral, when scratched or rubbed, is called the *streak*, which is best obtained by means of a hard tempered knife or a file. If the mineral is soft, it may be rubbed on a piece of rough porcelain. Those parts which have been much exposed to the air should not be chosen.

To discover the hardness of a mineral, it is necessary to try and find out which of the typical specimens of the scale of hardness (commencing with the hardest and proceeding to the lowest) is scratched by it.

#### SCALE.

1. Talc (such as soapstone), easily scratched by the finger nail.
2. Rock salt (also gypsum, zinc, &c.), not easily scratched by the nail, nor can scratch a copper coin.
3. Calc spar (transparent), both scratches and can be scratched by a copper coin.
4. Fluor spar, not scratched by a copper coin and does not scratch glass.
5. Apatite, with difficulty scratches glass and is easily scratched by a knife.
6. Felspar, scratches glass and is not easily scratched by a knife.
7. Quartz, not scratched by a knife and easily scratches glass.
8. Topaz, harder than flint.
9. Corundum, emerald, &c.
10. Diamond, scratches any substance.

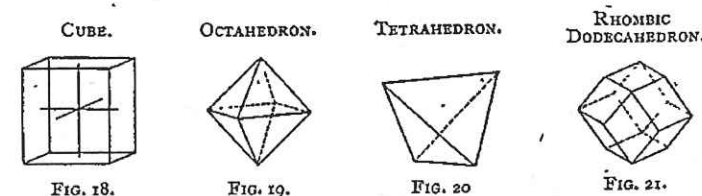
The hardness of minerals that can be scratched by the finger nail is  $2\frac{1}{2}$  or less, and by a copper coin less than 4.

Minerals may often be recognised, or their nature verified, by the crystallization they assume.

The following are the fundamental forms of crystals:—

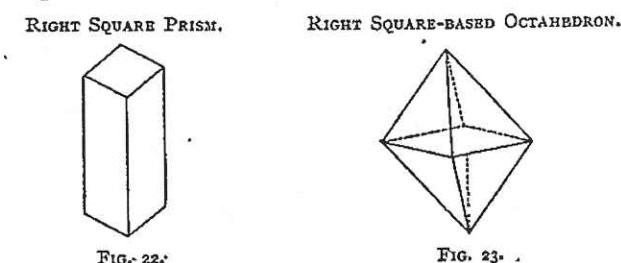
1. Regular system (called the cubic, octahedral, &c.). In this system there are three equal axes (imaginary) passing through the same point and at right angles to each other.

For examples—



2. Square prismatic system (has three axes at right angles to one another of which two are of equal length).

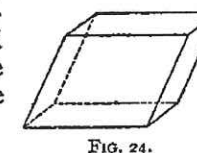
Examples—



3. Right prismatic system (right rhomboidal or rectangular prismatic system), in which the three axes are of unequal length.

4. Oblique prismatic system, which includes the right rhomboidal prism and the oblique rhombic prism. The three axes may be of unequal length while two are at right angles.

Example—



5. Double oblique prismatic system in which three axes are unequal.

6. Rhombohedral system (regular hexagonal system). There are four axes, three of which are in the same plane and inclined to one another at an angle of  $60^\circ$ .

Example—



FIG. 25.

Crystalline form is not always sufficient evidence to rely upon in the determination of a mineral, as several different minerals assume the same or nearly the same shapes of crystal; and, again, certain particular minerals are found of more than one shape.

As examples of the first are carbonates of lime, lime and magnesia, zinc, iron, where the angle of the rhombohedral forms only varies between  $105^\circ$  and  $108^\circ$ .

Sulphur, iron pyrites, specular iron, carbon, are examples of the second kind.

In addition to the already-mentioned characteristics useful in the determination of the nature of a particular mineral, some peculiar properties belonging to certain minerals should be noted.

For instance, some iron, cobalt, and nickel ores are attracted by the magnet; some minerals—such as fluor-spar, topaz, carbonate of lead, quartz, and calc spar—become electrified by friction; others—such as calamine—become so when heated. Others, when rubbed, yield a peculiar odour; some—such as fluor spar—are phosphorescent, that is, yield a peculiar light when heated; while many possess a characteristic taste.

## CHAPTER V.

### METALS AND METALLIC ORES: THEIR CHARACTERISTICS.—TESTING.—OCCURRENCE, &c.

Antimony; sulphide.—Bismuth.—Chromium; oxide.—Cobalt; tin white; earthy oxide.—Copper; native; glance; pyrites; grey; ruby; black oxide; silicate; malachite.—Gold; detection of and distinguishing tests; peculiarities; panning out; mechanical assay; sluicing; native gold, &c.—Iron; pyrites; magnetic pyrites; arsenical pyrites; hæmatite; magnetic iron ore; brown iron ore; franklinite; vivianite; copperas; spathic ore.—Lead; galena; carbonate; pyromorphite; chromate; sulphate; rough method for obtaining lead from galena.—Manganese; black oxide; wad, &c.—Mercury; native; cinnabar; chloride, selenide; to obtain metal from ore.—Nickel; kupfernickel; white; emerald; hydrated silicate.—Platinum; native.—Silver; native; brittle ore; glance; hornsilver; ruby ore; silver in carbonate of lead.—Tin; tinstone; bellmetal ore.—Zinc; calamine; silicate; red zinc ore.

#### ANTIMONY.

The metal is usually found combined with sulphur, arsenic, or sulphur and lead. If a mineral be supposed to contain antimony in any form, the presence of the metal may be known by treating the specimen with carbonate of soda on charcoal in the R.F.\* of the blowpipe, when, if it be present, a bluish white incrustation is formed, which (being volatile) disappears when exposed to the O.F. and R.F.; in the latter case with green coloration. The bead is white and brittle. To confirm:—Scrape the incrustation off and treat with hydrochloric acid and zinc on platinum foil. A film of antimony will be left on the latter. If a piece of ore containing antimony be heated in an iron spoon, white fumes will rise and coat the rim. The behaviour of anti-

\* (N.B.—O.F. = Oxidizing Flame; R.F. = Reducing Flame; B.F. = Blowpipe Flame; S.G. = Specific Gravity; H. = Hardness.)



mony with borax or platinum wire before the blowpipe flames is, when cold, in O.F. = colourless,  
in R.F. = colourless to grey.

Combined with lead, or bismuth, or copper, other tests have to be resorted to.

Antimony is a most undesirable metal to be associated with other metallic compounds in a vein, as it interferes with the ordinary smelting processes.

Sulphide of Antimony (*grey antimony*).

The ore from which the antimony of commerce is extracted—

*Crystallization*—right rhombic prisms.

*Colour*—lead grey.

*Streak*—lead grey and blackish.

*Lustre*—shining and metallic.

*Structure*—brittle: thin laminæ slightly flexible.

H.—2; S.G.—4.5 to 4.7.

*Composition per cent.*—antimony, 73; sulphur, 27.

Fuses in the flame of a candle. Before B. flame and on charcoal yields white fumes with odour of sulphur. When pure, is soluble in hydrochloric acid. Can be distinguished from an ore of manganese, like in appearance, by its being easily fused and its diagonal cleavage.

There are about ten varieties of this last ore, the streaks of which vary; all the ores, however, are soft, and can be scratched by the finger nail. Grey antimony occurs with ores of silver, lead, zinc, or iron, &c., and is often associated with heavy spar and quartz. Found in metamorphic and igneous rocks.

#### BISMUTH.

Found chiefly in the native state, but also in combination with sulphur, oxygen, tellurium, carbonic acid, &c. It yields a yellow incrustation in the O.F. of the blowpipe.

The oxide, sulphide, arsenide, combined sometimes with copper, lead, &c., vary in colour, hardness, and specific gravity. Bismuth glance, containing 81 per cent. of the metal, is usually of a lead-grey colour. When heated in a closed tube yields a sulphur sublimate. On charcoal before

the B.F. sputters and deposits a yellow incrustation leaving metallic bismuth.

#### CHROMIUM.

The oxide is chiefly found with iron.

*Colour*—brownish black.

*Lustre*—submetallic.

H.—5.5; S.G.—4.5.

Before the B.F. yields a green bead with borax. Chromate of lead is rarely found.

#### COBALT.

Compounds of cobalt, when heated on charcoal before the B.F., yield whitish metallic spangles, which can be attracted by a magnet. The metal moistened on paper with nitric acid gives a red solution, which with hydrochloric acid affords a green stain on drying.

Treated with borax in either B.F. it yields a deep blue lead. Before testing, metallic compounds should be roasted, to drive off volatile matter.

#### Tin White Cobalt.

*Crystallization*—octahedral, cubical, and dodecahedral, &c.

*Breaks* with uneven and granular fracture.

*Colour*—tin white and greyish.

*Streak*—greyish black.

H.—5.3; S.G.—6.4 to 7.2.

*Composition*—cobalt and arsenic.

Before the blowpipe it colours borax and other fluxes blue. Affords pink solution with nitric acid.

#### Earthy Oxide.

Usually massive.

*Colour*—blue black or black.

H.—1 to 1.5; S.G.—2.2 to 2.6.

*Composition*—oxides of cobalt and manganese.

#### Cobalt Bloom.

*Lustre*—pearly.

*Colour*—peach-red, crimson; sometimes grey or greenish.

*Streak*—paler; powder-lavender.

*Composition per cent.*—oxide of cobalt, 37.6; the remainder, arsenic and water.

Gives off arsenical odour when heated. Behaviour with fluxes in the B.F. same as other cobalt ores.

In Great Britain cobalt ore is found in cavities in limestone of the carboniferous age. In Norway and other countries a variety of tin white cobalt is found in gneissic and primitive rocks. In Germany deposits of cobalt are found in limestone over copper slates.

#### COPPER.

If a specimen is supposed to contain copper, it should be examined either by means of the blowpipe or chemicals.

With carbonate of soda on charcoal before the B.F., nearly any copper ore is reduced and a globule of metallic copper obtained. Heated with borax or microsmic salt in the O.F. there results a green bead when hot, a blue one when cold. Most copper compounds, when heated in the inner flame, impart a green colour to the outer one. Copper compounds are, for the most part, soluble in nitric acid. If a piece of polished iron or the bright point of a penknife be dipped into the acid solution, it will be slightly coated with metallic copper if any exist in the ore. Ammonia added to an acid solution affords a green colour, and, in excess, a blue one. In the absence of a blowpipe or chemical apparatus, the presence of copper in a substance may be detected in this way:—First, roast the mineral and drop it, when hot, into some grease and expose it to the heat of a flame, which will show a green colour if copper exists. Or, if the mineral be well powdered, mixed with some fat and salt, and placed in the fire, the presence of copper will be known by the blue or green colour.

Again, if the powdered mineral be mixed with a little charcoal and roasted for about one hour, and then vinegar be poured on it and allowed to remain for a day or so, copper will produce a blue colour, afterwards becoming green.

#### Native Copper.

Found in treelike, mosslike, threadlike shapes, in octahedral crystals, grains, &c.

*Colour*—copper red.

Is ductile and malleable.

H.—2.5 to 3; S.G.—8.5 to 8.9.

Can be tested by the blowpipe or chemicals like other copper ores. Usually carries silver. Found chiefly in North and South America, also in Cornwall, Wales, &c.

#### Copper Glance (*vitreous copper ore*).

*Crystallization*—rhombic prisms. Is slightly sectile.

*Colour*—blackish grey, tarnishing to blue or green.

*Streak*—blackish grey, sometimes shining.

H.—2.5 to 3; S.G.—5.5 to 5.8.

*Composition per cent.*—sulphur, 20.6; copper, 77.2; iron, 1.5.

Before the blowpipe gives off sulphur fumes, fuses easily in the outer flame, and boils, leaving a globule of copper. Is fusible in a candle flame. Is rather like sulphide of silver, but the button left after exposure to B.F. shows the difference. If the mineral be dissolved in nitric acid, and the point of a penknife be placed in it, a slight copper coating will be formed if the metal is present, whereas, if a piece of bright copper be placed in it, a slight coating of silver will be formed if silver be present.

#### Copper Pyrites (*chalcopyrite*).

*Crystallization*—tetrahedral, also massive, &c.

*Colour*—brass yellow, sometimes tarnished and iridescent.

*Streak*—greenish black and unmetallic.

H.—3.5 to 4; S.G.—4.15.

*Composition per Cent.*—sulphur, 34.9; copper, 34.6; iron, 30.5.

Before the B.F., it fuses to a magnetic globule. If fused with borax, metallic copper is the result. Tested in acid, like other copper ores. Is sometimes mistaken for gold, iron pyrites, or tin pyrites; but it crumbles when cut, whereas gold can be cut in slices. Is of a deeper colour than iron pyrites, and yields easier to the knife, nor does it strike fire like iron pyrites. It may be distinguished from

tin pyrites by the blowpipe and other tests. If the ore be hard and of a pale yellow colour, it is considered to be poor in copper.

Variegated copper pyrites (containing 60 per cent. of copper) is of a pale reddish yellow colour.

#### Grey Copper (*tetrahedrite*).

When containing silver, Fahlerz.

*Crystallization*—tetrahedral, &c.

*Structure*—brittle.

*Colour*—between steel grey and iron black, sometimes brownish.

*Streak*—between steel grey and iron black, sometimes brownish.

H.—3 to 4; S.G.—4.75 to 5.1.

*Composition per cent.*—copper, 38.6; sulphur, 26.3; antimony and arsenic, zinc, iron, silver, &c.

It sometimes contains 30 per cent. of silver in place of part of the copper. After roasting, yields a globule of copper before the B.F. When powdered and dissolved in nitric acid, the solution is brownish green. The ore can be distinguished from any silver ore by the blowpipe and chemical tests. The darker the colour the less arsenic in it.

#### Red Copper Ore (*ruby copper*).

Found massive, earthy, granular, &c.

*Crystallization*—octahedral, and dodecahedral.

*Structure*—brittle.

*Lustre*—adamantine, or submetallic. Is subtransparent or nearly opaque. Detached crystals look rather like spinel rubies.

*Colour*—deep red, ruby colour, though it is often iron grey on the surface.

*Streak*—always brownish red.

H.—3.5 to 4; S.G.—6.

*Composition per cent.*—copper, 88.78; the remainder oxygen.

Heated in a tube closed at one end, it darkens. Yields globule of copper before the blowpipe. Dissolves in nitric acid.

#### Black Oxide of Copper.

Usually found on the surface, due to the decomposition of a sulphide or other copper ore. Black copper at the top of a lode may indicate some other copper compound deeper down. If the dusty powder be rubbed between the fingers and dropped on a flame, the latter will be coloured green.

#### Silicate of Copper.

Usually as an incrustation, massive, &c.

*Colour*—bright green and bluish green.

H.—2.3; S.G.—2 to 2.3.

*Contains* 40 to 50 per cent of oxide of copper.

Is rather like malachite in colour, but when dissolved in nitric acid a precipitate is left, whereas malachite is quite dissolved.

#### Malachite (*green carbonate of copper*).

Found in botryoidal or stalactitic masses, and as an incrustation, &c.

*Structure*—fibrous.

Nearly opaque.

*Colour*—emerald green.

*Streak*—a paler green than the colour.

H.—3.5 to 4; S.G. 3.6 to 4.

*Contains* about 70 per cent. of copper.

Before the blowpipe it becomes blackish. With borax before the B.F. it forms a green globule, and eventually yields a copper bead.

Completely dissolves in nitric acid, and so differs from other ores of a similar appearance.

The *blue carbonate* is very like the above; but its crystallization is a rhombic prism, and its streak bluish.

It is impossible to enumerate more than a few of the localities where copper ore is found and its manner of occurrence. It occurs in rocks of every age and in both lodes and deposits. The usual ore in a copper lode is pyrites, which is decomposed into black oxide at the surface. In Cornwall the copper lodes, which generally run east and west, are more productive in the slates than the granites.



The New Red Sandstone of Cheshire and Shropshire contains certain deposits of copper, chiefly malachite; and in the Carboniferous Limestone of Shropshire are also deposits of the same ore as well as pyrites. Copper pyrites veins traverse green slates and porphyritic rocks in the north of England. Not to mention the variety of lodes which run through rocks of various age of North America, the following are a few examples of the position of certain deposits.

In the Eastern States there are deposits in the New Red Sandstone, also in the Carboniferous Limestone and Silurian rocks. In the Lake Superior district, where so much native copper is found, deposits occur in sandstones and shales, underlying greenstone, &c. There are also lodes running through the various strata. Deposits of ruby copper ore occur in Arizona between quartzose and hornblende rocks and limestone. Lodes and deposits in Chili are worked in hornblende and felspathic quartz rocks. The celebrated Burra Burra mine in Australia, from which splendid lumps of malachite are familiar objects in museums, consists of an immense irregular deposit of malachite and other copper ores in limestone and harder rocks, as well as in the soil. Copper deposits occur elsewhere in schistose, hornblende, quartzose rocks, &c., and pyrites bearing lodes through rocks of various ages.

#### GOLD.

To detect free or native gold in a piece of specimen rock, in sand or gravel, the sample should be carefully examined by means of a magnifying glass, if the eye is insufficient. The particles of gold, if present in the free state, will probably be distinct, whether wet or dry, and can easily be distinguished by an expert from discoloured mica, iron, or copper pyrites. Gold presents the same colour from whatever direction it is looked at. To the prospector this is a guiding test. If a gold grain be detached from a rock or selected from sand or gravel, it can be flattened out by hammering and can be cut in slices, whereas those substances likely to be mistaken for gold are reduced to powder when pounded. Iron pyrites is too hard to be cut by a

knife, while copper pyrites affords a greenish powder. Besides, pyrites ore, when heated, gives off a sulphury odour. Mica, which when discoloured may be frequently mistaken for gold, is not sectile, and has a colourless streak; it can thus be distinguished from the precious metal. It may be well, too, to know that a speck of gold is not altered in colour or appearance by hydrochloric acid. As the quantity of gold in rock is usually very small—and to be payable it need not be otherwise—the most and only accurate way of determining its quantity is by means of scorification or fusion in a crucible, and afterwards by the cupellation process. This, however, is not always practicable in an out-of-the-way place, and, consequently, more simple means are generally sought for by prospectors in order to obtain a rough assay; and as gold is usually, though not always, met with in the pure metallic state, such are to be in a great measure depended upon. At the same time, it must be remembered that frequently the gold occurs as a very fine powder, invisible to the eye or even under a magnifying lens, and also that the grains—probably due to sulphur or arsenic—may be coated with a film, which prevents them from being recognised, and also from being capable of amalgamation with mercury until they have been roasted or undergone some operation.

To "pan out" gold-bearing matter, the gravel, sand (or rock powdered but not too finely), is placed in a flat-bottomed basin or pan, the diameter of which is about a foot, and two or three inches wider at the top than at the bottom. The pan, three-quarters full of ore, should be placed at an inclined position under water, or else water poured into it, and by shaking and agitating the contents of the pan by a kind of oscillatory motion, the lighter portions of the ore are allowed to run over the side of the vessel, until, after much washing, the heavier particles, such as gold, iron sand, &c., settle at the bottom. The iron sand, if magnetic, can be separated from the yellow metal by a magnet, or else can, when dry, be blown away by a gentle blast of air. The wooden vessel, called in Brazil a batea, serves the same purpose as the "pan."

The following is another method of obtaining the free

gold from a quantity of ore. Finely powder a quantity of ore along with water. Add mercury, at the rate of about 1 oz. of mercury to 8 lbs. of ore, and, if obtainable, a little cyanide of potassium. Grind the whole for two or three hours until the gold and mercury thoroughly amalgamate. Add water, and when the amalgam has settled at the bottom of the vessel pour the lighter matter off, collect the amalgam and squeeze it through chamois leather. The residue must be heated to drive off any mercury remaining.

On alluvial diggings, the operation of washing the gold dirt is usually conducted by means of sluices, having an inclination of about 8 feet in 12 feet. These sluices consist of a series of troughs formed by planks nailed together, the length of each being about 10 or 12 feet, the height 8 inches to 2 feet, the width 1 to 4 feet. By making one end of the bottom plank of each trough 4 inches narrower than at the other, the troughs can be telescoped into one another, and so a sluice of very great length can be formed. Across the inside of the bottom planks small narrow strips of wood, 2 inches or so thick, and 3 or more inches wide, are fixed across, or sometimes at angles of 45°, to the side of the trough at short intervals apart. Running water washes downwards the earth thrown into the sluice, which is open on the top side, and the gold dust accumulates (sometimes assisted by the aid of mercury allowed to trickle out of a vessel from riffle to riffle) in front of the bars, while the lighter matter is washed downwards.

#### Native Gold.

Found as grains; laminæ, sometimes threadlike; nuggets, &c.

Colour—yellow.

H.—2.5 to 3; S.G.—12 to 20.

With carbonate of soda on charcoal before B. F. it yields a yellow bead, easily hammered out or cut. If the powdered ore be dissolved in aqua regia (4 parts hydrochloric and 1 part nitric acid), a purple precipitate will be formed, when protochloride of tin is added to the solution.

Gold, nearly invariably in a native state, is very widely distributed over the globe, and is obtained from the gravel,

sand, clay, "drift beds," washed down from gold-bearing strata, or else from quartz lodes traversing the older slaty and metamorphic rocks and less abundantly in granite. It is also found scattered about in rocks of a granular nature. The ordinary gold-bearing lodes and deposits occur as represented in Fig. 26, which represents the structure of the Ural Mountains. Iron pyrites, copper pyrites, magnetic iron, blende, galena, &c., are some of the metallic minerals often very commonly associated with gold in a lode, the iron pyrites in veins of a gold-bearing district

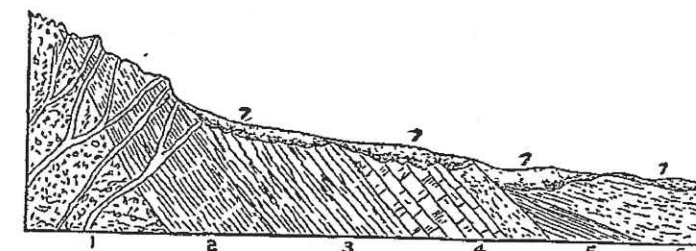


FIG. 26.—SECTION SHOWING THE TWO CONDITIONS UNDER WHICH GOLD IS USUALLY FOUND.

Granitic and gneissic rocks, often containing gold finely disseminated. 2, Micaceous, talcose, and argillaceous slaty rocks, Laurentian and Cambrian. 3, Silurian and Devonian strata. 4, Carboniferous limestone and grits. 5, Coal measures. 6, Permian and newer rocks. 7, 7, 7, Drift filling hollows in rocks, with gold, especially at the base of the drift.

nearly, if not always, containing a certain amount of the precious metal. On the surface of a lode the gold specks may perchance be noticed, by the eye or lens, in the cavities of the brown honeycombed quartz rock, although free gold may be invisible in the pyrites rock deeper in the lode and unexposed to atmospheric and other changes affecting the surface portions.

Gold is sometimes found as a telluride (as in Colorado and elsewhere in Western America), with antimony, arsenic, bismuth, &c., while all beds of rivers flowing from mountainous districts are worth prospecting.

Considering that there are few, if any, countries in the world where gold has not been found, it is unnecessary to

cite more than a few of the leading places and some of the conditions under which it has been met with.

#### AUSTRALASIA.

*Victoria.*—In quartz reefs, mostly through Lower Silurian rocks, and a lesser number through Upper Silurian. The direction of the majority of the first set is W. of N., that of the remainder E. of N. Not only have the ordinary alluvial deposits, as generally found near the surface in drifts washed down from the gold-bearing lodges in the higher land, been extremely rich, but also (as in some parts of California) the beds of ancient streams which have been covered by other aqueous deposits over which lava once flowed. The following diagram will exemplify the position of such a rich "gutter":—

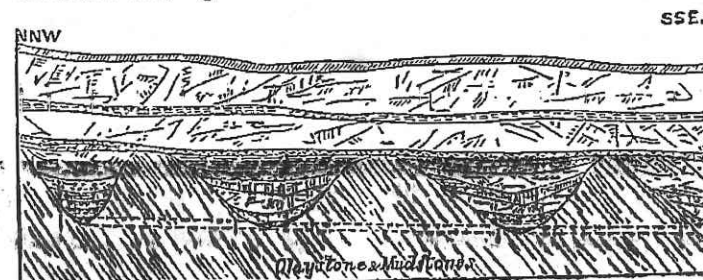


FIG 27.—SECTION OF THE OLDER DRIFTAL GOLD DEPOSITS NEAR BALLARAT.  
Scale: Hor. 1"=10 chains; Vert. 1"=320 feet.  
a, Drift. b, Basalt. c, Black and red clays. d, Basalt. e, Light coloured clays  
f, Basalt. x x x, Auriferous drift.

*New South Wales.*—In deposits chiefly derived from greenstone associated with Silurian and Devonian beds, &c.

*Queensland.*—In quartz veins, mostly through metamorphic rocks, and in alluvial deposits derived from these. The bluish coloured quartz is most productive.

*New Zealand.*—In beds of rivers, in valley bottoms, and on flat land as a deposit, sometimes in a conglomerate formation, along the sea-shore mixed with magnetic iron, in glacial drifts, &c. In quartz veins through metamorphic

rocks, the best veins running in a direction varying from N. to N.E., also in veins through a blue tufa formation.

*New Guinea.*—In auriferous black sand. In a deposit of decomposed slate, quartz rock, and conglomerate, above which are leaf-bearing clays.

#### ASIA.

*India.*—Gold is found in a very great many different localities, and both in veins and alluvial deposits. In the Wynaad are gold-bearing reefs running through granitic and metamorphic rocks.

*Ceylon.*—In veins through chloritic and micaceous rocks.

#### AMERICA.

*Canada.*—In alluvial deposits above talcose and other schists; in lodes through syenitic granite, &c.

*Nova Scotia.*—In quartz lodes through serpentine.

*California.*—In extensive alluvial deposits at the base of the Sierra Nevada, in the beds of modern and ancient streams, in magnetic iron sand, in lodes through granitic and gneissic rocks of the Cambrian age, in seam diggings which consist of decomposed bedrock with irregular seams of auriferous quartz. (See Fig. 1.)

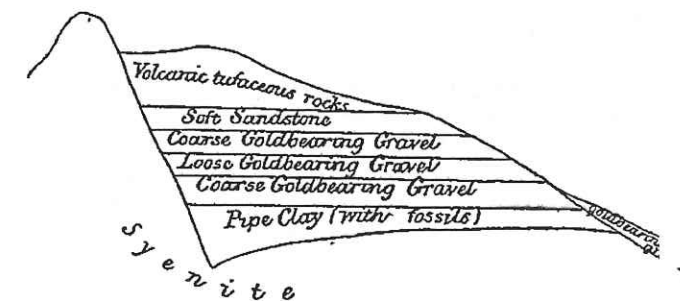


FIG. 28.—SECTION OF SPANISH PEAK DEPOSITS (CALIFORNIA).

In Placer county the lodes running E. and W., also N. and S., traverse syenite, also metamorphic slate.

In Nevada county certain lodes run N.W., and also N.E., the country rock being granite, greenstone, and slate; gene-



rally speaking, the lodes run through metamorphic schists, or greenstone, alternating with belts of syenite.



FIG. 29.—SECTION OF A PART OF TABLE MOUNTAIN (CALIFORNIA).

Throughout the whole of Western America, in the Rocky Mountains regions, such as Colorado, Montana, Dakota, New Mexico, &c., placer diggings and auriferous lodes are, and have been, worked in very many places. As a rule, the lodes run through granitic rocks and metamorphic schists and slates, the quartz being associated with iron and copper pyrites, galena, zinc blende, silver ore, &c. In the Eastern States, the gold-bearing veins are of much the same nature as those above mentioned.

### IRON.

When heated before the blowpipe some of the ores are infusible, while most become, if not naturally so, attractable by the magnet. When the test is not destroyed by the presence of other metals, iron in a mineral when heated with borax on a platinum wire in the inner flame produces a bottle-green glass; in the outer, a dark red, when hot; a light red, when cold.

#### Iron Pyrites (*mundic*).

*Crystallization*—usually cubical; also octahedral, &c.

*Lustre*—frequently bright metallic.

*Colour*—yellow of different shades.

*Streak*—brownish black.

H.—6 to 6.5; S.G.—4.5 to 5.

*Composition*—about half iron and half sulphur.

Strikes fire with steel, and has slightly peculiar smell when broken. If heated before B.F., sulphur fumes are given off, and eventually a globule of metal, attractable by the magnet, is obtained. The powder of iron pyrites is very slowly soluble in nitric acid. This ore carries gold in either a small or great quantity, and is generally to be found in gold-bearing and other lodes, oxide of iron, colouring the quartz brownish, representing at the surface the decomposed iron pyrites such as exists in the vein deeper down.

The mineral is often mistaken for copper pyrites and sometimes for gold, but its being too hard to be cut by a knife is a distinguishing test. Iron pyrites is not employed for the extraction of iron; it is the chief mineral, however, from which sulphuric acid is obtained. In Spain are very rich deposits from which most of the ore brought to England is mined, although the Coal measures of this country are productive.

#### Magnetic Pyrites.

*Crystallization*—hexagonal prisms, &c.

*Colour*—between copper red and yellow, inclining to bronze.

*Streak*—greyish black.

H.—3.5; S.G.—4.4 to 4.6.

*Composition*—about 60 per cent iron, the rest sulphur.

In the outer B.F. on charcoal, a red oxide of iron globule is formed; in the inner flame, fuses and yields a black magnetic globule having a yellowish fracture. It is not so hard as iron pyrites, and is slightly attracted by the magnet.

#### Arsenical Pyrites (*mispickel*).

*Crystallization*—rhombic prisms modified on the angles, &c.

*Colour*—silver white.

*Streak*—greyish black.

*Lustre*—shining.

H.—5.5 to 6; S.G.—6.3.

*Composition*—about 35 per cent iron, the rest arsenic and sulphur; cobalt sometimes occurs in the ore.

Before B.F. a magnetic globule is obtained. Strikes fire with steel. Is found in tin veins of Cornwall and Bohemia, also with copper, iron, &c.

#### Specular Iron (*haematite*).

*Crystallization*—rhombohedral; some crystals are thin hexagonal tables with oblique edges.

*Colour*—dark steel grey in some varieties, but red in some earthy ones.

*Streak*—powder invariably dark cherry red.

H.—5.5; S.G.—4.5 to 5.3.

*Composition*—70 per cent. iron, the rest oxygen.

Infusible before B.F., but with borax gives a yellow glass in the outer flame, a green glass in the inner flame.

Varieties of this ore are:—

Specular iron—of a metallic lustre.

Red *haematite*—an opaque mineral, not of a metallic lustre, brownish or red in colour. Has a radiated structure.

Red ochre and red chalk—soft and earthy, generally containing a quantity of clay.

Jaspery clay iron—clay ironstone, &c.

~~Micaeous iron ore (a scaly variety) is used as the basis for a certain kind of paint.~~

#### Magnetic Iron Ore (*loadstone*).

*Colour*—dark iron grey with metallic lustre.

*Streak*—black.

*Structure*—brittle.

H.—5.5 to 6.5; S.G.—5 to 5.1.

*Composition per cent.*—peroxide of iron, 69; protoxide of iron, 31.

Infusible before B.F. Yields bottle-green glass when heated with borax in inner flame. If powdered, the iron can be separated from impurities by the magnet. Not acted on by nitric acid; but when powdered is soluble in hydrochloric acid. Masses of specular iron ore and magnetic iron may sometimes be mistaken for one another; the difference of streaks easily distinguishes them. This ore is the most important in the north of Europe.

#### Brown Iron Ore (*limonite*).

Sometimes earthy. Massive, with botryoidal and smooth surface, &c.

*Structure*—fibrous.

*Colour*—brownish yellow and coffee colour.

*Streak*—yellowish.

*Lustre*—dull or submetallic.

H.—5 to 5.5; S.G.—3.6 to 4.

*Composition*—85 per cent. of iron peroxide, of which seven-tenths is pure iron.

Before B.F. blackens and becomes magnetic. Gives bottle-green glass in the inner flame when heated with borax.

Varieties:—

Brown *haematite*—Botryoidal, stalactitic, &c.

Yellow and brown ochre—Earthy.

Bog iron ore—Of a loose, friable texture. Found as a black or brownish earth in low swampy ground.

Brown or yellow ironstone—Hard and compact.

#### Franklinite (*an American ore*).

*Colour*—dark black.

*Streak*—dark brown.

*Structure*—brittle.

*Composition*—66 per cent. peroxide of iron, manganese, and zinc.

In appearance is something like magnetic iron, but less metallic.

#### Copperas (*green vitriol*).

*Colour*—greenish white.

*Lustre*—glossy and subtransparent.

*Structure*—brittle.

Contains 25 per cent. of oxide of iron, also sulphur and water.

It is formed by the decomposition of iron pyrites.

#### Vivianite.

*Crystallization*—oblique prisms.

*Lustre*—pearly or glossy.

*Colour*—deep blue to green.

*Streak*—blue.

H.—1.5 to 2; S.G.—2.6.

*Composition*—42 per cent. protoxide of iron, phosphoric acid, and water.

Becomes opaque before the blowpipe.

#### Spathic Iron (*iron spar, carbonate of iron*).

Sometimes massive, with a crystalline structure.

*Crystallization*—hexagonal, rhombohedral, &c.

*Lustre*—glassy or pearly.

*Colour*—yellowish grey to rust colour; becomes brownish red to black on exposure.

*Streak*—uncoloured.

H.—3 to 4.5; S.G.—3.7.

*Composition*—62 per cent. of protoxide of iron, carbonic acid, &c.

Before B.F. it blackens and becomes magnetic. Colours borax green. Dissolves in nitric acid, but, though a carbonate, does not effervesce much, unless in a powdered state. Heated in a closed tube, often decrepitates, and turns black and magnetic.

Clay ironstone of the Black Band seam is an impure variety.

The oxides and carbonates of iron are the principal ores, and their gangues are calcareous, argillaceous, siliceous, or bituminous, their value depending in a certain degree on the associated minerals. Thus:—In spathic ores, 5 to 15 per cent. of manganese or carbonaceous matter in a clay stone is an advantage; whereas some iron ores are decreased in worth by being associated with iron pyrites, &c.

Magnetic iron ore occurs in granite, gneiss, schist rocks, clay slate, and limestone.

Remarkable deposits of red hæmatite occur in Carboniferous, Cambrian, Silurian, and Devonian rocks. In Cumberland, North Lancashire, and Wales, veins run north and south in mountain limestone. Brown iron ore deposits

occur in Carboniferous Limestone and Lower Coal measures in several places in England and Wales; also in the Lias, Oolite, and Lower Greensand of some places. In Spain brown hæmatite is found in a cretaceous formation. Spathic ores occur in carboniferous rocks, as well as in Devonian and older rocks. Clay ironstone is found in shales and clays of the Coal measures, also in Lias formation.

The Titaniferous iron ore, sometimes massive, but usually in the form of dark black sand washed down from the rocks in the country around, is very plentiful in some parts of North America, New Zealand, &c., and is often auriferous. Unfortunately the ore is rather refractory.

#### LEAD.

Lead compounds, if heated with carbonate of soda on charcoal before the blowpipe flame, yield malleable metal, and also a yellow oxide of lead incrustation.

If dissolved in nitric acid, the white sulphate of lead may be thrown down as a precipitate by adding sulphuric acid; or as chloride of lead by adding hydrochloric acid.

As, however, other chlorides might be formed at the same time, the precipitate should have ammonia added to it, when, if chloride of lead, it is unaltered.

#### Galena (*the principal ore of lead*).

*Crystallization*—cubical and cleavable in cubes, also octahedral.

*Lustre*—shining metallic; the surface may be dull, but the fracture is brilliant.

*Colour*—lead grey.

*Streak*—lead grey.

H.—2.5; S.G.—7.5.

*Composition*—80 per cent. lead, the rest sulphur.

Unless heated carefully in the B.F. it is apt to decrepitate, but eventually yields a globule of lead. Can be decomposed by nitric acid. Galena can be distinguished from silver and other ores by blowpipe and chemical tests as well as by its characteristic cubical cleavage. The ore usually contains a perceptible amount of silver, and its presence may



be observed by dissolving the ore in nitric acid and dipping a piece of bright copper into the solution, when a silver film will be formed. A galena ore should always be carefully assayed for silver, as sometimes it is very rich. It is an erroneous notion that fine-grained galena is more argentiferous than a coarse-grained one, though it might be in a particular district.

#### Carbonate of Lead (*white lead ore*).

Compact, earthy, or fibrous masses.

*Crystallization*—prismatic, &c.

*Structure*—brittle.

*Lustre*—glassy or adamantine; is transparent or translucent, when pure.

*Colour*—white or greyish (sometimes with a bluish tinge).

*Streak*—colourless.

H.—3 to 3.5; S.G.—6.5.

*Composition*—75 per cent. of lead, the rest carbonic acid, &c.

Before B.F. a lead bead is obtained.

If dissolved in nitric acid, and a piece of clean zinc be dipped in the solution, brilliant lead laminae will be precipitated on the zinc.

#### Pyromorphite.

*Colour*—greenish, sometimes bright grass green, the hexagonal crystals having a greasy lustre, also yellowish, brownish, and sometimes dull violet.

*Streak*—whitish or yellowish.

*Lustre*—more or less resinous; generally translucent.

H.—3.5 to 4; S.G.—6.5 to 7.

Contains 78 per cent. of lead, as well as phosphorus, &c. Heated on charcoal before the B.F., a globule is formed which crystallizes on cooling, while a yellow oxide of lead incrustation is seen on the charcoal.

With carbonate of soda in R.F. yields a lead bead. Is soluble in nitric acid.

#### Chromate of Lead.

Is a yellowish mineral containing protoxide of lead and chromic acid. It blackens before the blowpipe and leaves shining globules of lead in the slag. Produces a yellow solution in nitric acid.

#### Sulphate of Lead.

A white, grey, greenish, or bluish, translucent or opaque mineral, with an adamantine lustre. Contains protoxide of lead and sulphuric acid. Rather like carbonate of lead, but is softer and does not effervesce in an acid.

Galena (generally mixed with other metals) is the usual and most productive ore of lead, and is very frequently extremely rich in silver. It is found in rock formations of various ages in lodes, pockets, flats, &c.

The carboniferous or mountain limestones of England yield most of the lead ore, while it is also worked in the "killas" of Cornwall, a Devonian formation.

It also occurs in Great Britain and other countries in the Lower Silurian rocks, in granites, gneiss, &c.

The carbonate of lead deposits of Leadville, Colorado, best known for being richly argentiferous, occur between blue limestone and porphyry (Fig. 30).

Galena is generally associated with quartz, carbonate of lime spar, fluor spar, sometimes barytes, copper and iron pyrites, &c.

For the assay of Galena, see Chap. IX.

The following is a simple method of obtaining lead bullion (though not the proper amount) from an ore, and may be of use to the prospector. Erect a square furnace of rough stones. Place rough logs of wood at the bottom, above this split wood, then broken-up ore, and then wood. The fire should be lighted at the entrance, and the lead allowed to run out into a basin.

#### MANGANESE.

The principal ore is the black oxide (grey manganese or pyrolusite).

Found compact or granular; the black powder in the cavities will soil the fingers. Small brilliant crystals, like

cut steel, are sometimes met with; also botryoidal masses with a fibrous structure.

*Lustre*—submetallic.

*Colour and streak*—black.

H.—2 to 2.5; S.G.—4.8 to 5.

*Composition*—63.3 per cent. manganese, the remainder oxygen.

Effervesces briskly with borax before the B.F.

The oxide of manganese, when heated with borax on a platinum fire, colours the bead violet to black when hot, reddish violet when cold, in the O.F.; colourless when hot, colourless to rose colour when cold, in the R.F.

Wad (bog manganese) is an earthy or compact variety of manganite, a mineral which differs from the black oxide in containing 10 per cent. of water. *Psilomené* is a hydrous oxide of manganese which contains baryta and other substances. When heated with borax produces a violent effervescence.

Manganese spar (of a reddish colour) consists of manganese protoxide, silica, &c.

Manganese deposits occur in different parts of the world and seem to have been derived from the metal originally scattered about in rocks of the ancient formations.

#### MERCURY.

If heated in a glass tube together with carbonate of soda, mercury compounds yield a sublimate of mercury on the cold part of the tube.

#### Native Mercury.

Is sometimes found as fluid globules of a tin-white colour. S.G.—13.6. Is volatile before the B.F., and easily dissolves in nitric acid.

#### Cinnabar (*sulphide of mercury*).

This is the ore from which commercial mercury is obtained. Sometimes found massive, with a granular structure, sometimes in a crystallized form, the crystals being brilliant, transparent, and of a beautiful carmine colour.

*Colour*—generally red, sometimes bright red; also brown, brownish black, &c.

*Streak*—red.

*Lustre*—unmetallic.

*Structure*—sectile.

H.—2 to 2.5; S.G.—6 to 8.

*Contains* 86 per cent. of mercury, the rest sulphur.

Is volatile before the B.F. Soluble in aqua regia (4 hydrochloric acid and 1 nitric acid), but not in either hydrochloric or nitric acid.

If the powdered ore be placed together with quicklime in an iron pan and gently heated, a globule of mercury will be found at the bottom of the pan.

If the powdered ore be placed in a glass vessel capable of standing heat, such as a thin oil flask, and exposed to a strong flame, the mercury will form a sublimate on the upper and cool part of the vessel.

By placing powdered ore in the mouth of a tobacco-pipe, closing the mouth with clay, and exposing the bowl to a fair heat the mercury may be collected on a cool surface, held so that the fumes given off may be condensed.

A gold coin or a piece of clean copper placed in the fumes will soon have a deposit of mercury on its surface.

#### Chloride of Mercury (*horn quicksilver*).

Is crystalline and granular, of a dirty white or ash grey colour, and a yellowish streak.

H.—1 to 2; S.G.—6.48.

#### Selenide of Mercury.

Of a steel or lead grey colour and metallic lustre; occurs in Mexico.

The following are some of the places where cinnabar is found and its mode of occurrence:—

*California*—As deposits in cretaceous rocks, &c.

*Idria in Illyria*—Disseminated through bituminous schist, limestone, or grit.

*Spain*—In veins traversing a micaceous schist.

*Italy*—In small veins through mica slate.

*Mexico*—There is a mercury-producing vein in pitchstone porphyry.

*South America*—There is a mercury-bearing ore in strata of shales and sandstones, &c.

Generally speaking, mercury ores occur in both early and late geological formations.

#### NICKEL.

To test the presence of nickel in a mineral, by means of the blowpipe, requires great care. If heated on charcoal, together with carbonate of soda in the inner flame, a grey metallic powder, attractable by the magnet, is formed. If heated with borax on platinum wire in the outer flame, a hyacinth red to violet brown glass results when hot, a yellowish or yellowish red when cold. In the reducing flame a grey bead is formed.

*Kupfernickel (Arsenical nickel).*

Generally massive, kidney-shaped, columnar, arborescent, &c.

*Crystallization*—hexagonal.

*Colour*—copper red (greyish or blackish when tarnished).

*Streak*—paler.

*Lustre*—metallic.

*Structure*—brittle.

H.—5 to 5.5; S.G.—7.3 to 7.7.

*Composition*—35 to 45 per cent. of nickel, the rest chiefly arsenic.

Often resembles native copper, but is harder. Soluble in nitric acid, and forms a green solution which becomes a violet blue by the addition of ammonia.

*White Nickel (nickel glance).*

*Crystallization*—cubical.

*Colour*—silver white or steel grey.

*Streak*—greyish black.

*Lustre*—metallic.

*Structure*—brittle.

H.—5.5 to 6; S.G.—6.4 to 6.7.

*Composition*—25 to 30 per cent. nickel, the rest arsenic.

*Emerald Nickel (a carbonate of nickel).*

Is of a bright green colour, and contains 28.6 per cent. of water.

In addition to the above may be mentioned the prolific hydrated silicate of nickel found in New Caledonia.

*Colour*—green, light or dark.

*Streak*—light green.

S.G.—2.2 to 2.86; H.—2.5.

Gives off water when heated. Fuses in borax before B.F., and gives the ordinary nickel bead. Is a silicate of nickel and magnesia, with iron, &c. Good specimens yield 12 per cent. nickel. Is found in lodes and pockets in serpentine rock. Matrix, cellular silica. Sometimes in a lode, the nickel is replaced by cobalt.

Excepting the New Caledonia ore, the principal ore is kupfernickel. It occurs in many countries of Europe, in metamorphic, syenitic rocks, &c., and is generally associated with ores of cobalt, copper, silver, lead, &c. In Canada, a deposit of nickel ore occurs between magnesian limestone above and serpentine below.

#### PLATINUM.

This metal is found in the native state. Occurs in grains and masses.

*Colour*—whitish grey or dark grey.

*Streak*—whitish grey or dark grey.

*Lustre*—metallic.

H.—4 to 4.5; S.G.—19.6 to 21.

Iridium and osmium, &c., are usually mixed up with it. Wholly insoluble before the blowpipe flame. Can be dissolved in aqua regia (4 parts hydrochloric and 1 nitric acid), forming a yellowish solution, which becomes a bright red colour when protochloride of tin is added.

On account of the high specific gravity of platinum, it can



be "panned out" from sand or gravel just the same as gold or other heavy metals.

If platinum be dissolved in aqua regia by boiling, and salammoniac be added to the filtered solution, a granular precipitate of a bright yellow or reddish yellow is formed. When this precipitate is heated, the metal, as "spongy platinum" powder, is obtained.

Platinum, though it is found in minute quantity in some metal-bearing veins, is usually met with as grains, generally flattened, in gold-bearing alluvial deposits, probably washed down from crystalline rocks.

#### SILVER.

Silver ores are easily fused before the blowpipe flame, either with or without carbonate of soda. The resulting globule of metal, of its characteristic white colour, can be readily hammered out or cut by a knife.

If the powdered mineral, supposed to contain silver, be dissolved in nitric acid and the solution be filtered or decanted, the presence of silver may be known by adding a solution of common table salt or of hydrochloric acid to the original solution. If silver be present, a white precipitate is thrown down. As chloride of lead or mercury might also be precipitated, let it be remembered that chloride of silver is soluble in ammonia, whereas chloride of lead is unchanged, and mercurous chloride blackened by it.

A very bright piece of copper, placed in the original solution, would be coated with metallic silver, if any existed. To test for copper, a bright knife-blade dipped into the solution would be coated with a copper film.

Sometimes, if a lump of silver-bearing ore be placed in a very hot fire, it will show white particles of the metal on the outside.

The metal silver soon tarnishes, when exposed to the action of sulphur; thus, if boiled along with the yolk of an egg, it will blacken.

#### Native Silver.

Found as wire silver, in thin sheets, in tree-like shapes, &c., and as octahedral crystals.

*Colour and Streak*—silver white. When found in veins is usually tarnished on the surface.

*Structure*—easily cut and hammered out.

H.—2.5 to 3; S.G.—10.1 to 11.1.

The silver usually contains gold and copper. Is recognised by the blowpipe and acids, as above mentioned. Native silver is often associated with iron rocks, native copper, &c.

#### Brittle Silver Ore (*sulphide of silver and antimony*).

Found massive, compact, in rhombic prism crystals, &c.

*Lustre*—metallic.

*Colour and Streak*—black or iron grey.

H.—2 to 2.5; S.G.—6.29.

*Composition*—When pure contains about 71 per cent. of silver, the rest antimony, &c.

With carbonate of soda before B.F. it decrepitates, but readily yields a silver lead. If the mineral be dissolved in nitric acid a piece of bright copper will be covered by a film of silver if placed in the solution. It is distinguished from silver glance by being brittle; whereas silver glance is soft and sectile, and chips can be cut off without crumbling.

#### Silver Glance (*sulphide of silver*).

A most important ore. Found massive, &c.

*Crystallization*—cubical, octahedral, &c.

*Fracture*—conchoidal or uneven.

*Colour*—blackish or lead grey (before exposure to the light has a bright metallic lustre).

*Streak*—same as colour, and shining.

*Structure*—Soft and sectile.

H.—2 to 2.5; S.G.—7.1 to 7.4.

Contains 87 per cent. silver, the rest sulphur. Is usually associated with the sulphides of lead, copper, iron, zinc, antimony, arsenic, &c., also with nickel and cobalt ores.

Before B.F. with carbonate of soda yields globule of metal. Known in acid solution by usual tests. Is similar in appearance to some copper and lead ores, but distinguished before the B.F. and by its malleability. Is fusible at the temperature of an ordinary flame.

**Horn Silver** (*chloride of silver*).

A soft mineral found massive; also in crystals. Is nearly opaque, translucent on the edges, and has a waxy appearance.

*Fracture*—conchoidal.

*Colour*—greenish white, pearl grey, &c.

*Streak*—shining and grey.

Cuts like wax.

Contains about 75 per cent. of silver, when pure.

Fuses in a candle flame. Before B.F. readily yields metal. The surface of a plate of iron is silvered by it when moistened and rubbed. Forms a large portion of the South American "pacos" and "Colorados" ores.

**Ruby Silver** (*pyrargyrite*).

Massive, granular, or as prismatic crystals.

*Lustre*—adamantine and submetallic.

*Colour*—Sometimes black, reddish black, or brilliant

*cochineal colour.*

*Streak*—lovely crimson red.

H.—2 to 2.5; S.G.—5.4 to 5.6.

Contains about 60 per cent. of silver, the rest arsenic, &c. Occurs with calcite, galena, &c.

The dark red silver ore is a sulphide of silver and antimony; the light red contains arsenic in the place of antimony. The ores of silver occur in veins traversing granitic and gneissic rocks, clay slate, mica schist, limestone, &c., and are usually associated with the ores of iron, copper, lead, zinc, &c.

In many parts of the world silver is chiefly obtained from lead ores, galena always containing more or less of the precious metal.

At Leadville, Colorado, America, where most extensive mines have been worked of late years, the silver is found in

the carbonate of lead deposit lying between a blue limestone formation below and a white porphyry above (Fig. 30).

The famous Comstock lode, Nevada, running north and south, and consisting of quartz (here and there calcite and decomposed rocks), and such minerals as sulphides of various metals, silver ore as argentite, and also native silver, gold, &c., lies between syenite above and metamorphic slaty rock below. In Mexico rich deposits of silver-bearing ore are found in limestone, also between slaty and porphyritic rocks, and traversing igneous and metamorphic formations. In

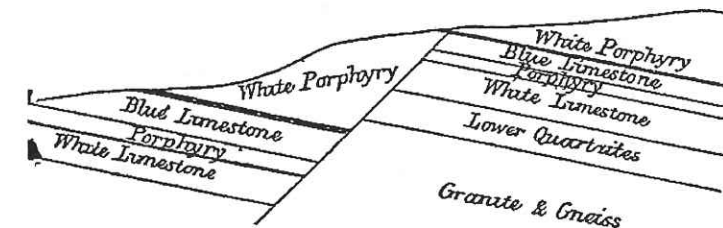


FIG. 30.

Chili chloride of silver and native silver are mined for in stratified beds above granitic rocks, the most productive ones belonging, it is supposed, to the Cretaceous period. In Peru are certain silver-bearing beds overlying porphyry and with limestone at the sides. In Colorado and other Western States and Territories of America chloride of silver deposits occur, and fissure veins, the number of which is legion, generally containing ores of silver and other metals mixed with the quartz.

**TIN.**

When a tin-bearing mineral is heated before the blowpipe with carbonate of soda or charcoal, white metallic tin is yielded. By dissolving this in hydrochloric acid and adding metallic zinc, the tin will be deposited in a spongy form. In the blowpipe assay, tin leaves a white deposit behind it, which cannot be driven off in either flame. If it be moistened with nitrate of cobalt solution, the deposit becomes bluish green, and this test distinguishes it from other metals.

The most important ore is—

**Cassiterite** (*tin ore, oxide of tin, tinstone*).

Massive and in grains.

*Crystallization*—in square prisms, octahedral, &c.

*Colour*—when pure, colourless and transparent, but usually brownish, or black, or grey, with a bright lustre when crystallized.

Nearly opaque, and a resinous, submetallic lustre.

*Streak*—brownish.

H.—6 to 7; S.G.—6.5 to 7.1.

(Is almost as hard as quartz, scratching glass, &c.)

*Contains*, when pure, 78 per cent. of tin.

Is infusible alone before the B.F., but with carbonate of soda metallic tin is yielded.

**Stream Tin**

Is the ore found as rolled fragments of tinstone in the beds of streams or low-lying gravels.

**Wood Tin**

Is an uncrystallized fibrous form of the mineral rather like dry wood, generally of a light brown colour, variegated with yellowish and dark concentric bands.

Tin ore sometimes resembles dark garnets, black zinc blende, &c.

**Bellmetal Ore** (*sulphide of tin*).

A rare ore, found massive and crystallized in cubes.

*Colour*—steel grey.

*Streak*—black.

*Structure*—brittle.

H.—4; S.G.—4.3 to 4.6.

*Composition*—27 per cent. tin; copper, iron, and sulphur.

Veins of tin ore traverse granite, gneiss, mica, slate, &c.

In Cornwall the lodes generally run east and west, and the average dip is 70°; some also run across these. The ore is also found as a series of small veins in friable granite; also in masses, and as stream tin, as well as in veins between certain rocks and parallel to their beds. The true veins

traverse granite and killas. In Queensland tin is obtained from a deposit, and also from lodes through granite rocks.

In Tasmania from deposits and from lodes in a porphyritic rock. In New South Wales quartz veins carrying tin run through granite. The alluvial deposits of the Malay Archipelago are doubtless derived from veins in granite.

**ZINC.**

Minerals to be tested for zinc should be treated along with carbonate of soda on charcoal, before the blowpipe. The presence of the metal is known by the incrustation on the charcoal (very luminous when strongly heated) which is when hot, yellow; when cold, white. If the incrustation be moistened with nitrate of cobalt and heated, a fine green colour results.

**Calamine** (*carbonate of zinc*).

This is the most important ore. Massive, stalactitic, and not quite transparent.

*Colour*—when pure, pearly white; but, owing to presence of iron oxide, &c., generally brownish, sometimes green.

*Streak*—whitish.

*Lustre*—pearly or glassy.

*Structure*—brittle.

H.—5; S.G.—3.3 to 3.5.

When pure, contains 52 per cent. of zinc; the rest, oxide of iron, carbonate of lime, and magnesia, &c.

Infusible alone before the blowpipe. Like other carbonates, effervesces in acid. Sometimes looks like calc spar.

**Zinc Blende** (*sulphide of zinc, commonly called Black Jack*).

Massive and fibrous; crystallizes in octahedrons and dodecahedrons.

*Colour*—when pure, yellow and transparent, but more usually, brownish red, garnet red, or blackish and translucent.

*Streak*—white to reddish brown.

*Lustre*—waxy.

H.—3.5 to 4; S.G.—4.



Some specimens become electric.

Contains nearly 67 per cent. zinc; the rest sulphur, &c.

Only fusible on the edges when heated alone on the blowpipe. Dissolves in nitric acid. If roasted in a glass tube, some of the sulphur is given off and a residue, zinc sulphate (white vitriol), is left. Zinc blende occurs with iron and copper pyrites, silver ores, &c.

#### Silicate of Zinc (*zinc glance*).

*Colour*—whitish, blue, brown, or green.

Not quite transparent.

*Streak*—whitish.

*Lustre*—pearly or glassy.

H.—4.5 to 5; S.G.—3.3 to 3.5.

Contains about 67 per cent. of zinc; the rest silica.

Before B.F. froths up and gives a phosphorescent light. Is infusible alone. With borax, yields a clear bead. If heated in sulphuric acid it dissolves, and the solution becomes gelatinous when cool.

#### Red Zinc Ore.

Granular or massive.

*Cleavage*—brittle slices, rather like mica.

*Colour*—bright red.

*Streak*—orange yellow.

*Lustre*—brilliant.

Not quite transparent.

H.—4 to 4.5; S.G.—5.4 to 5.6.

Contains about 80 per cent. zinc.

Infusible alone before the blowpipe. With borax, yields a transparent yellow glass. Dissolves in nitric acid.

The principal ore, calamine, occurs in veins, beds, and pockets, usually in limestones of Devonian, Carboniferous, or Oolitic age. Zinc blende is found in the limestones of Great Britain and elsewhere. It is often associated with several metals in a lode. In Cornwall there is a saying, "Black Jack rides a good horse;" that is, where zinc blende is met with at the top of a lode, copper may probably be met with deeper down.

## CHAPTER VI.

### OTHER USEFUL MINERALS AND ORES.

Black lead.—Coal; anthracite; bituminous; brown coal.—Bitumen; asphalt; naphtha; petroleum.—Gypsum.—Apatite.—Alum.—Borax.—Common salt.—Precious stones and gems; diamond.—Table of characteristics of various precious stones and gems.

#### GRAPHITE (*black lead*).

*Lustre*—metallic.

*Colour*—dark steel grey.

*Streak*—black and shining.

H.—1.2; S.G.—2.1.

Is greasy to the touch. Soils paper, if rubbed on it. Contains about 90 per cent. carbon; the rest, iron, lime, &c. Is infusible before the blowpipe and insoluble in acids. In Cumberland, England, blacklead-bearing strata are found in slate rocks interbedded with trappean rocks. In Ceylon, in the upper strata of Devonian formation. In the United States of America, in gneissic rock. Graphite is used in the manufacture of lead pencils, crucibles, &c.

#### COAL.

True coal (not lignite and brown coal) is usually found in beds or seams divided from one another by beds of shale, sandstone, grit, and clay, in the Coal measures belonging to the Carboniferous formation. The principal varieties are—

#### Anthracite.

A black, shining coal with sharp edges and conchoidal fracture. Streak, black. Does not soil the fingers. Is not easily lighted, but when alight gives out an intense heat and very little smoke. Contains 90 to 95 per cent. of carbon.

**Bituminous Coal.**

Has a rather more waxy appearance than anthracite. Colour, black. Streak, blackish. S.G. not more than 1.5. Varieties: pitching or caking coal, splint coal, cannel coal (having a fine compact texture and conchoidal fracture, capable of receiving a good polish, sonorous when struck), cherry coal, jet (which is blacker than cannel coal but more brilliant in lustre), contains 73 to 90 per cent. of carbon.

**Brown Coal or Lignite.**

Colour, brown or blackish. Resinous lustre, sometimes dull. 50 to 90 per cent. carbon. Although in England and many other countries the carboniferous rocks contain large coal beds, the most useful mineral is met with in other formations, such as in New Zealand, where lignite is found of a recent as well as of the Jurassic or Cretaceous age. In various parts of North America the lignite-bearing strata belong to the Tertiary and Cretaceous period, &c.

**BITUMEN.**

Found both in the solid and fluid state. Is inflammable and has a peculiar odour.

Varieties:—

**Asphalt.**

A solid black or brownish mineral. Fracture, conchoidal with glassy lustre. H.—2. When pure, will float on water. In Trinidad there is a lake of it  $1\frac{1}{2}$  miles in circumference. It is solid near the edges, but boiling in the centre. Asphalt is found in the mountain limestone of Derbyshire and Shropshire, also in granite with quartz and and fluor spar in Cornwall.

**Naphtha (mineral oil).**

A fluid of a yellowish colour. Has a peculiar odour. Will float on water.

**Petroleum.**

A fluid, darker in colour than naphtha, sometimes black. Naphtha and petroleum contain 84 to 88 per cent.

of carbon, the rest hydrogen. Asphalt, in addition to carbon and hydrogen, contains oxygen and a little nitrogen. In California it is found in strata belonging to the Tertiary age. In Colorado and other Western States, to the Cretaceous. In North Carolina, to the Triassic. In West Virginia, to the Coal measures. In Kentucky, it occurs near the base of Carboniferous Limestone. The West Pennsylvania oil strata belong to the Devonian age.

**GYPSUM (alabaster).**

*Crystallization*—derived from a right rhomboidal prism.

*Colour*—white, grey, black, &c.

When pure, is clear and translucent, and of pearly lustre. In hardness most varieties can be scratched by the nail. S.G. 2.3. In composition is a sulphate of lime. Before B.F. becomes white and opaque, and is easily crumbled. All varieties, when heated and reduced to powder and mixed with water, harden while drying. Gypsum (from which plaster of Paris is manufactured) occurs in recent Tertiary formations, and also in the various other formations as old as the Silurian. Is often associated with beds of rock salt as in Cheshire.

**APATITE.**

A mineral very rich in phosphate of lime, and, after treatment, used for dressing the soil.

*Cleavage*—not well marked.

*Colour*—white, grey, greenish, &c.

*Streak*—white.

Is transparent to opaque.

H.—4.5 to 5; S.G.—2.9 to 3.3.

Some varieties are phosphorescent when heated. Before B.F. fuses with difficulty on the edges. In Canada occurs extensively in limestone of the Laurentian age.

**ALUM (hydrated sulphate of potash and alumina).**

Is best known by its astringent, sweetish taste.

H.—2 to 2.5; S.G.—1.8.

Soluble in its own weight of boiling water.

Found in clay slates.

**BORAX** (*borate of soda*).

Colour—white.  
Is opaque.  
Lustre—vitreous.  
Fracture—conchoidal.  
Structure—brittle.  
Taste—sweetish alkaline.

Before B.B. it swells up and becomes opaque, but melts afterwards to a transparent globule. Found as a deposit in lagoons. In Tuscany, Nepal (India), and in various parts of America, are borax-bearing lakes.

**NITRE** (*saltpetre*).

Is usually found native as an efflorescence on the soil. Is soluble in water. When thrown on live coal, causes vivid combustion. Composed of potash and nitric acid.

**COMMON SALT** (*chloride of sodium*).

Colour—white or greyish, sometimes rose red.  
Crackles when heated.  
Taste—saline.

Salt deposits are found in strata of various ages, and often associated with gypsum, magnesia, soda, &c.

**PRECIOUS STONES.**

Precious stones belong to such formations as granitic, gneissic, porphyritic rocks, &c., and are generally found in the *débris* of such; and although certain diamond-bearing soils may be of a comparatively recent age, they are for all that made up of the constituents of the older rocks.

Diamonds are usually met with in alluvial soil, often on gold-diggings. In some India fields there is a diamond-bearing conglomerate, made up of rounded stones cemented together, which lies under two layers, the top one consisting of gravel, sand, and loam, the bottom one of thick black clay and mud.

In Brazil the most precious of all gems is obtained from a conglomerate of white quartz, pebbles, and light-coloured sand, sometimes with yellow and blue quartz and iron sand. In South Africa the diamondiferous alluvial deposits consist

chiefly of nodules of granite, basalt, sandstone, greenstone, &c., and in it are garnets, jasper, agates, &c., as well as the diamonds. There are both dry and river diggings.

The method of detecting the diamonds is the same in principle everywhere. The larger rocks are thrown aside, the gravel sifted, and the pebbles (separated from the sand) are easily cleaned and examined.

Diamonds, spinel ruby, or garnet are never found as six-sided prisms, and thus several commoner crystals can be distinguished from them; nor are emeralds, sapphire, zircon found as cubes, octahedrons, or rhombic dodecahedrons. With the exception of diamond (which is pure carbon), precious stones may be divided into two classes—those which have alumina as the base, and those which have silica. Of the first are the sapphire, ruby, emerald, &c.; of the second are the amethyst, opal, cat's-eye, agates, &c.

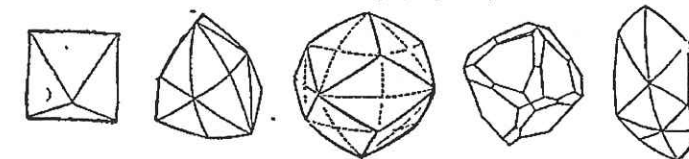


FIG. 31. FIG. 32. FIG. 33. FIG. 34. FIG. 35.  
USUAL FORMS OF DIAMONDS.

To estimate the value of an uncut diamond there is no fixed rule, on account of the fluctuation of prices.

Generally speaking, the value of diamonds of different weights varies as the squares of their weights in carats. (N.B.—1 carat =  $3\frac{1}{2}$  grains troy.)

Value of a diamond of A carats  $\left\{ \begin{array}{l} = A \text{ multiplied by } A \text{ multiplied by} \\ \text{of } A \text{ carats} \end{array} \right. = \text{some number dependent on the value of 1 carat.}$

Thus a diamond of 200 carats is 400 times more valuable than one of 10 carats.

The hardness and lustre are the most reliable tests to detect this choicest of all gems. A diamond will scratch any substance (except boron); but in testing it care has to be taken that the angles be not broken, as, notwithstanding hardness, it is rather brittle. Some of the characteristics of the principal precious stones are given on the two following pages.



TABLE OF CHARACTERISTICS

Name of Precious Stone or Gem.	Colour, &c.	S. G.	H.	Crystallization.
Diamond	White or colourless; sometimes tinged with yellow or other colours. Reflects light brilliantly. Has adamantine lustre.	3.5	10	Octahedral, dodecahedral, faces sometimes curved (Figs 31-35). The octahedral is the common form in India.
Ruby	Red.	3.9	9	Rhomboidal.
Topaz	Various.	to 4.2		
Sapphire	Pale blue.			
Emerald	Beautiful green.			
Amethyst	Violet blue.	3.8	8	Octahedral and dodecahedral.
Spinel	Bright red or scarlet.			
Ruby				
Cat's-eye	Greenish grey and translucent. When polished, displays beautiful internal reflections, like a cat's eye.	3 to 3.6	8.5	
Opal	Milk white, pearly grey, &c. When moved in various positions displays beautiful colours.	2 to 2.3	5.5 to 6.5	Uncrystallized.
Garnet	Deep red.	3.5 to 4.3	6.5 to 7.5	Dodecahedral, &c.
Turquoise (phosphate of alumina, coloured by copper)	Bluish green.	2.6 to 3		Reniform; stalactitic incrustation.
Quartz	White and other colours, sometimes transparent.			
Jasper	Tile red, yellow, purple, &c.			
Cornelian	Bright red.	2.65	7	Hexagonal, prism, &
Onyx, &c.	An agate, with colours arranged in flat horizontal layers.			
Corundum (pure alumina)	Blue, grey, brown, &c.	4	9	Granular, six-sided prisms, &c.

\* To ascertain the nature of the refraction, place the stone on the other side. If the refraction

F VARIOUS STONES AND GEMS.

Refraction.	Electrical Properties.	Fusibility.	Action of Acids.
Simple.	Positive.	Infusible.	Not acted on.
Double.	Retain electricity for hours.	Infusible.	Insoluble.
Simple.	None.	Infusible; changes colour before B.F.	Insoluble in hydrochloric, partly soluble in sulphuric.
Double.	Retains electricity.	Infusible.	
Double.	Positive.	Infusible; gives off water before B.F. and becomes opaque.	More or less soluble.
Simple.	Electrical by friction.	Fusible.	Imperfectly soluble.
Double.	None.	Infusible; in mitrass decrepitates and turns black.	Soluble.
Double.	Positive.	Infusible; but fuses with effervescence with carbonate of soda before B.F.	Insoluble.
Double.		Unaltered alone before B.F., and with soda; gives blue colour with cobalt solution; fuses with difficulty with borax.	Insoluble.

out of the eye and let a small object be moved slowly about on the double, two images will be seen.

## CHAPTER VII.

## COMPOSITION OF VARIOUS ROCKS.

Granite.—Schists.—Gneiss.—Serpentine.—Basalt.—Pitchstone.—Obsidian.—Pumicestone.—Sandstones.—Limestones.—Dolomite.—Clays.—Nature of certain minerals in igneous and metamorphic rocks; quartz; felspar; mica; talc; chlorite; hornblende; augite; olivine.—Matrices of veins; quartz; fluor spar; calc spar.

## Granite.

Composed of quartz—white, black, grey, &c.—in rather irregular grains; mica, silvery white or metallic black (sometimes replaced by hornblende); potash felspar of a white, pink red, or yellowish colour, and crystallized. Contains 70 per cent. silica, with alumina, lime, magnesia, alkalis, oxide of iron, &c.; or 40 per cent. felspar, 30 to 40 per cent. quartz, 10 to 20 per cent. mica.

In foliated granite the grains are arranged in layers. In graphic granite the felspar is arranged in the quartz, or the quartz in the felspar, something like the letters in Oriental writing. Micaceous, quartzose, felspathic granite are varieties in which mica, quartz, felspar respectively predominate. **Syenite is a variety of granite free from quartz, and chiefly composed of hornblende and potash felspar.**

**Porphyry is a compact felspathic rock of the nature of granite, having felspar crystals, mica, quartz, chlorite, &c., imbedded in it, which give it a speckled appearance.**

## Schists.

Mica schist consists of fine layers of quartz and mica; talc schist consists of fine layers of quartz and talc; chlorite schist consists of fine layers of quartz and chlorite; hornblende schist consists of fine layers of quartz and hornblende.

*N.B.—In the so-called igneous rocks sometimes the minerals are distinctly crystallized, sometimes of a very compact appearance like broken porcelain.*

## Gneiss

Is made up of the same minerals as granite, only containing them in parallel layers.

## Serpentine.

A greenish, grey, brown, &c., mineral, opaque and translucent. Breaks with a conchoidal fracture. H.—2.25 to 4; S.G.—2.5 to 2.6. Massive, foliated, or fibrous, and in appearance pearly, resinous, or waxy. Before B.F. whitens and gives off water. Contains 40 to 44 per cent. of magnesia, 40 per cent. silica.

## Basalt.

When broken, of a black, bluish, greenish, greyish brown, &c., colour, though usually pale drab colour on the surface. Contains 40 to 60 silica, 11 to 28 alumina, oxides of iron, manganese, lime, magnesia, &c.

## Pitchstone.

A volcanic rock resembling obsidian, but instead of having a glassy hue is duller and of a pitchy appearance. Is slaty, compact, scaly, &c., and breaks with a conchoidal fracture. H.—5.5; S.G.—2.2 to 2.3. Before B.F. melts to a grey enamel or porous glass.

## Obsidian.

A glassy volcanic rock with a conchoidal fracture. Usually black or grey, although of several other colours. H.—6 to 7; S.G.—2.2 to 2.6.

Contains 70 to 80 per cent. silica; alumina, alkalis, &c. Before B.F. melts to a foaming consistency, a glass or enamel.

## Pumicestone.

A spongy, porous, volcanic rock, usually, though not always, greyish white or of some light colour. Floats on water, although the powder has a specific gravity above 2. Is very brittle. Before B.F. melts to a white enamel. In composition, nearly the same as obsidian. Hardly acted on by acids.

**Sandstones.**

These rocks may always be recognised by their appearance, being made up of particles of sand cemented together. The grains (chiefly silica) are very hard. Do not effervesce in acid.

**Limestones.**

Rocks chiefly composed of carbonate of lime, and consequently, like other carbonates, effervesce when a little hydrochloric acid is dropped on. Though infusible before the B.F., limestone glows with a very bright light.

**Varieties :—**

*Chalk*—Soft, earthy, whitish and without lustre.

*Granular or compact limestone.*

*Oolite*, which consists of spherical grains, and in appearance like the roe of a fish. *Marly limestone, marble, calc spar, &c.*

**Dolomite.**

A colourless, white, sometimes yellow, green, or pale red mineral, of a pearly, resinous, or vitreous-like appearance is composed of carbonates of lime and magnesia. Is infusible before the B.F., but glows with a bright light. Though a carbonate, does not effervesce much in acid.

**Clays.**

Contain usually about 40 to 50 per cent. silica, 30 alumina; water as well, sometimes, as iron, lime, potash, &c. When mixed with water clays may be kneaded by hand into various shapes. Usually, when in a dry state, very absorbent of water. Become hard when dried. Adhere to the tongue. Some clays give out a disagreeable earthy smell when breathed upon. Are generally infusible in a furnace.

**Varieties :—**

*Slate Clay*—Colour, greyish or greyish yellow. Fracture slaty. When ground and reduced to paste with water can be used as firebrick.

*Common Clay* (used for making bricks, tiles, and coarse pottery). *Loam.*

*Pipe Clay*—Colour, white or greyish white; feels greasy. Surface polishes when pressed by the finger.

*Potters' Clay*—More easily fusible. Of various colours; generally red, yellow, green, blue, &c., becoming red or yellow when burnt.

*Kaolin* (porcelain clay). The purest form of clay. Contains 40 to 42 per cent. alumina, 46 to 48 per cent. silica, and water. It is really decomposed felspathic rock. Kaolin is greasy to the touch, friable in the hand, and does not easily form into a paste with water. When heated, hardens and retains a white colour.

**NATURE OF CERTAIN MINERALS**

*Met with in various of the Igneous and Metamorphic Rocks.*

**Quartz** (see Matrices).

**Felspar.**

Colour usually white or red, occasionally grey, black, or green. Felspars scratch glass and can be scratched by quartz; but not well by a good knife. S.G.—2.5 to 2.7. Lustre commonly vitreous or pearly on the more perfect cleavage planes. Some varieties are iridescent or opalescent. With the exception of Labradorite, felspars are unacted on, or imperfectly so, by acids. Contains silicate of alumina with soda, potash, lime (sometimes two or more of these).

**Mica.**

A finely foliated mineral of pearly lustre. In colour sometimes white, grey, or black, and when exposed sometimes yellowish. Cleavage very perfect in one direction. Laminæ very flexible. Usually occurs in thin scales; sometimes in large plates. Harder than gypsum, not so hard as calc spar. S.G.—2.5 to 3. Mostly fusible before B.F. Not readily acted on by hydrochloric acid. In its composition are silicates of alumina, with potash, magnesia, lime, iron, manganese, &c.



**Talc.**

A greenish, yellowish white, or sometimes colourless mineral of a pearly or resinous lustre. Is greasy to the touch; soft; yields to the finger-nail; can be cut into laminae which bend but are not elastic. H.—1; S.G.—2.6 to 2.8. Before blowpipe is infusible, but whitens. Becomes red with nitrate of cobalt solution. Is not soluble in either hydrochloric or sulphuric acid. Composition per cent.: silica, 62; magnesia, 27; alumina, water, iron, &c.

**Chlorite.**

A dark green, generally foliated and scaly mineral. Streak, greenish grey. H.—1 to 1.5; S.G.—2.7 to 2.96. Soluble in hot sulphuric acid. Contains silicates of alumina and magnesia and water.

**Hornblende.**

There are many varieties of this mineral, mostly of a greenish black, and also whitish colour (those containing lime and magnesia, without iron, being light). Streak, white or slightly coloured. Lustre, vitreous. H.—4 to 6. S.G.—2.9 to 4. Scarcely acted on by hydrochloric or nitric acid. Unaltered when heated in a closed tube. More or less fusible before the B.F. Composed of silicates of lime, magnesia, also iron, alumina, &c.

**Augite.**

A dark green or blackish mineral, in composition like hornblende, of a pearly or vitreous lustre. Is met with in volcanic rocks.

**Olivine.**

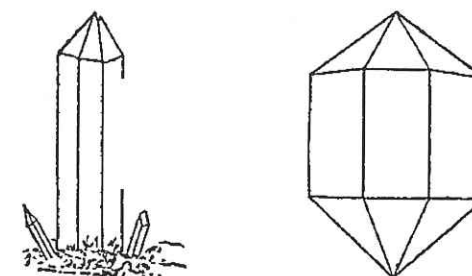
A green or brownish transparent or translucent mineral of a vitreous lustre, found imbedded in lava or basalt. Is harder than felspar and equals quartz. S.G.—3.3 to 3.5. Dissolves in sulphuric acid, less readily in hydrochloric acid; the silica gelatinizes. Consists of silica, magnesia, iron, and oxygen.

**MATRICES OF VEINS.**

The principal ones are:—

**Quartz.**

Of nearly every colour, generally white or brownish, sometimes bluish, as in the Queensland gold districts, and of a dull glassy lustre. Scratches glass, &c., but cannot be scratched by a file or knife. Is infusible



FIGS. 36 and 37.—COMMON CRYSTALS OF QUARTZ.

alone before the B.F., but with carbonate of soda it dissolves to a glass. Is insoluble in acids, except hydrofluoric. If two pieces of quartz are rubbed together in the dark, a phosphorescent light is seen. When crystallized, is usually in six-sided prisms. H.—7; S.G.—2.6 to 2.7. At or near the surface of a lode the quartz has very often a honey-comb appearance, and stained brown, yellow, purple, or other colour, due to decomposed iron or copper pyrites, or other metallic substances, which may be expected to be found deeper down. Quartz is very nearly pure silica.

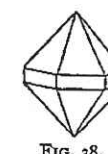


FIG. 38.

**Fluor Spar.**

Though by no means so common a matrix as quartz, it often forms or is mixed with the gangue of copper, lead, or silver-bearing lodes. Is usually purple, sometimes yel-

low, white, or green, and occasionally blue. If a piece be heated in a dark place, a phosphorescent light may be noticed. Fluor spar might be mistaken for a precious stone; its softness, however, is a distinguishing feature.

Crystallizes most commonly in cubes, octahedra, &c. Crystals are transparent or translucent. H.—4; S.G.—3.14 to 3.18. Is brittle. When heated in a closed tube, decrepitates and phosphoresces.

Gives opaque beads when heated with borax and microsmic salt before B.F. If melted in a tube with microsmic salt it gives off vapour of hydrofluoric acid, which corrodes the glass.

If the powdered mineral be dissolved in sulphuric acid, the gaseous acid will corrode glass, and even siliceous stones. Blue John is a name given by Derbyshire miners to a blue fluor spar. Composition: lime, 51; fluorine, 48.

**Calc Spar (carbonate of lime).**

Generally transparent or translucent. Crystallization rhom-

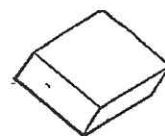


FIG. 39.

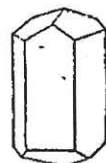


FIG. 40.



FIG. 41.

COMMON FORMS OF CALC SPAR.

bohedral, &c. Some common forms being as above. The faces are sometimes very brilliant. H.—3; S.G.—2.5 to 2.8. Is colourless, topaz, or honey yellow, grey rose, violet, &c.

Is infusible before the B.F., gives a very bright light, and is eventually reduced to quicklime. It effervesces when acted on by an acid.

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## CHAPTER VIII.

### TESTING BY THE WET PROCESS,

#### Systematic Plan of Procedure.

In testing a mineral by the wet process, the method is to powder and thoroughly dissolve it in some liquid, usually an acid, or mixture of acids, and then to recognise the presence of some known metal or metals by the peculiarity of the precipitate produced, when a reagent has been added to the solution. If the mineral is likely to contain sulphur or arsenic or other such volatile substances in its composition (such as iron pyrites, copper pyrites, galena, &c.), a good plan is to powder and roast it in order to drive off the sulphur, and to leave the metallic portions in the form of oxide, and thus in a proper condition for easy examination. There are certain minerals, as graphite, cinnabar (the principal ore of mercury), some oxides, sulphates, chlorides, and a number of silicates, that are not soluble in acid. So as to simplify the testing of such as these, it is just as well to add to the powdered mineral about four times the weight of carbonate of soda, and to melt them in a crucible or other apparatus, so as to leave the metallic portion in a condition to be dissolved by hydrochloric acid; but let it be remembered that the above methods are only suggested to render the tests more accurate than they would otherwise be.

Notwithstanding that the blowpipe tests are those chiefly to be depended upon, the following wet ones may be of use in determining the presence of some of the metallic bases in many of the common ores met with; and the apparatus required is not very large, consisting of three acids, (hydrochloric, nitric, sulphuric), potash, ammonia, protochloride of tin (if convenient) for the gold test, copper, and zinc, a few test tubes, porcelain capsules, &c. The principal objection to the wet process is the inconvenience of carry-

ing about powerful acids; at the same time, any chemist, if desired, will put them in strong and properly stopped bottles, which, when packed carefully in the compartments of a small box, will stand a good deal of knocking about.

The finely powdered mineral should be dissolved in hydrochloric acid or nitric acid (the latter being a substitute for roasting, and is the most suitable when the substance is a sulphide, or arsenide, or metallic alloy), and reagents added.

Place a little powdered ore in a test tube or other convenient apparatus (such as a porcelain dish), add a little water and pour in nitric acid; heat this over a spirit or other flame for a short time.

The clear solution is called the original solution, and (if there be any undissolved matter left as a residue at the bottom of the tube) should be filtered or decanted into another test tube.

To the clear solution add a little hydrochloric acid, when, if a precipitate is formed it is,

#### Chloride of Lead, Chloride of Silver, or Mercurous Chloride.

Pour all the liquid off, and then shake this precipitate with ammonia and observe the results:—

If dissolved it is chloride of silver.	If blackened it is mercurous chloride.	If unchanged it is chloride of lead.
Confirmatory test for silver: add potash to the original solution and a brown precipitate would be produced.	Confirmatory test for mercury: add potash to original solution and a black precipitate would be produced. Metallic copper (clean) placed in the solution would become silvery-looking.	Confirmatory test for lead: add to original solution some sulphuric acid, and stir; a white precipitate, sulphate of lead, would be formed at the bottom of the tube.

Suppose, however, that no precipitate was formed on the addition of hydrochloric acid to the original solution. The presence of some of the metallic bases is best determined by

passing sulphuretted hydrogen gas through the acid solution. If a precipitate is formed it may, if *black*, show the presence of mercury, lead, bismuth, platinum, tin, gold, and copper; if *yellow*, of tin, antimony, arsenic, or cadmium; but should no precipitate be formed, the addition of other reagents has to be made to determine the presence of iron, zinc, manganese, copper, nickel, and cobalt, &c.

The prospector will, however, find that usually his best plan is to take portions of the original solution, and to test them, one at a time, as follows:—

To separate portions of the original add reagents as in Table on the next page.

The presence of antimony may be noted by adding a little hydrochloric acid to the original solution, and introducing a piece of zinc—a sooty black precipitate will be the result.

To test a mineral for gold, the specimen must be thoroughly dissolved in aqua regia (4 parts hydrochloric and 1 nitric acid), then protochloride of tin added.

The slightest trace of gold will cause the purple precipitate (called purple of cassius) to be formed; if a bright red solution results, there is platinum present.

Though, generally, testing for a metal in a mineral is most satisfactorily performed by means of the blowpipe, there are cases in which there is great difficulty in obtaining proper results; for instance, when several metallic compounds are combined in the same specimen. Under such or other circumstances, individual tests, by means of the addition of reagents to the original solution, are most useful.

Again, the action of an acid on a mineral frequently enables the operator to determine whether the mineral is a silicate, a carbonate, &c.—if the former, sometimes by gelatinization; if the latter, by effervescence; and the evolution of nitrous acid vapours will suggest that copper, copper pyrites, or some metalliferous substance, not an oxide, may be present.



REAGENTS TO BE ADDED TO THE ORIGINAL SOLUTION.

I.	II.	III.
DILUTE SULPHURIC ACID.	AMMONIA IN EXCESS.	POTASH IN EXCESS.
White precipitate shows the presence of lead.	Blue colour shows presence of copper or nickel. Copper may be known by introducing the point of a polished knife-blade into the solution mixed with hydrochloric acid in excess: a coating of copper is formed.	Blue precipitate shows presence of cobalt. Light green " nickel. White precipitate becoming brown when shaken in the air " manganese. Brown or green, which becomes brown on exposure to the air " iron. White " " zinc. Yellow " " mercury.
	White precipitate shows presence of stannous or mercurous. By dissolving the precipitate with dilute hydrochloric acid, and introducing a piece of bright copper and boiling, the mercury, if present, will form a silvery coating on the copper.	
	Red brown precipitate shows presence of iron peroxide.	

## CHAPTER IX.

### ASSAY OF ORES.

Various methods.—Fluxes, reagents, &c.—General treatment of ores. —Preparation of the sample.—Weighing, &c.—Assay ton.—To construct a simple button balance and to use it.—Dry assay for gold and silver.—Apparatus and procedure.—Fusion in a crucible.—Scorification.—Cupellation.—Indications of the presence of metals known from cupel stains.—To make cupels.—Dry assay for lead in galena, tin, antimony.—Wet assays for gold, silver, lead, copper, iron.—Roasting.—Mechanical assay of ores.

To determine the amount of metal in an ore, there are two kinds of assay adopted.

The dry method (*i.e.* by fusing the powdered ore with or without fluxes).

The wet method (*i.e.* by the agency of liquids).

In the principal wet assay, the ore is thoroughly dissolved in acids, and, by the addition of reagents, precipitates containing the metals are thrown down.

In some assays, particularly those of copper, iron, zinc, and silver, a standard solution of known strength is added to the original solution by allowing it to drop gradually from a graduated burette, and when a certain change of colour has been produced, by reading off the graduated mark at the top of the liquid column in the burette the amount of metal in the ore can be accurately determined by a slight calculation. At the same time more simple methods will, if not strictly accurate, give good results, and are more likely to be adopted by the prospector.

Then there is the assay by mechanical means (for instance the separating of the lighter portions from heavier by means of water, as in the "panning out" of gold in a deposit), (see GOLD, Chap. V.).

In dry assays, crucibles or scorifiers capable of standing very great heat, without breaking, are generally used for con-

ducting the operations, and in these the powdered ores, with or without fluxes, are exposed to heat in a furnace, the temperature varying according to the nature of the ore.

The principal fluxes employed are :—

Carbonate of Soda, or Potash, which forms fusible compounds with silica, &c.

Borax, which forms fusible compounds with lime, oxide of iron, &c.

Glass, Silica, Fluor Spar, Litharge, and others.

Reducing Agents are used, such as charcoal powder, cyanide of potassium.

Oxidizing Agents, such as atmospheric air (removing sulphur, &c., in the roasting process), nitre (which is very rich in oxygen), litharge, salt, &c.

Desulphurizing Agents (for removing sulphur), such as air (in the roasting process), iron nails, carbonate of soda, &c.

Agents to remove Arsenic, such as atmospheric air (in roasting process), nitre, &c.

Collecting Agents (for collecting silver or gold), such as lead, mercury, &c.

#### GENERAL TREATMENT OF ORES.

Specimens to be assayed should not be chosen to elicit a "good assay" only. They should represent dressed ore ready for shipment. When an average portion of rock has been selected, it should be carefully powdered, if possible, in a mortar, or, in the absence of a mortar, broken up into a few pieces; and these, rolled up in cloth or paper, should be powdered between two hard rocks. To prevent fragments from flying out of the mortar, a loose paper cover, with a hole in the centre for the pestle to pass through, will suffice. Some substances, especially those of a quartz nature, will be rendered easier to crush by first being heated and thrown into water. If the ore does not contain metallic particles, the operation of powdering and sieving is comparatively easy; when, however, metallic fragments are mixed

up with the bulk of the ore, they are very apt to become flattened out by hammering, and do not always present a metallic appearance. In this condition they may refuse to pass through the sieve, and an inexperienced person, not understanding that they may be the most valuable fragments of the sample, is inclined to throw them aside. In reality, they should be collected together and most carefully examined.

When fragments of the ore adhere to the mortar, a little powdered coke or charcoal should be stirred about in the mortar.

When a dry assay or analysis is intended, the best sieve to use is the one of sixty meshes to the inch; when an ordinary wet assay, the eighty-mesh one; but for the separation of heavy metals, such as gold, tin, &c., from the lighter matter, by means of water and motion, the ore need not be powdered very finely. A piece of fine muslin will, in the absence of a sieve, answer ordinary purposes tolerably well, if, when the powdered ore be placed in it, the muslin be gathered together at the corners and shaken gently. After the specimen has been thoroughly powdered it should be put back into the mortar and stirred a few times by the pestle in order to evenly distribute the light and heavy particles, and then by a quick overturning of the mortar deposited on a piece of dry paper (glazed if possible). The powder may then be gently mixed by a knife or spatula, and if there be too much in quantity divided into quarters, and one or more divisions selected for the assay. The ore can then be weighed very accurately on the ore balance, after which it is ready for assaying. If the assay is one for gold and silver, the resulting button of precious metal is naturally very small (and to weigh which the very delicate button balance is used), so that great accuracy in the original weighing of ore is necessary, as the following calculation has to be made:—If a weight of ore yields a certain weight of metal, what weight of metal in ounces will a ton of similar ore yield. If the ore is assayed for ordinary metals, such as lead, &c., then

$$\frac{\text{weight of resulting metal}}{\text{weight of sample of ore}} \times 100 = \frac{\text{percentage of metal in}}{\text{the ore.}}$$

For weighing gold, silver, or platinum, the troy weight is sometimes used; for weighing other metals, avoirdupois. The French decimal system of grammes and decimals of a gramme is convenient for both. (See APPENDIX.)

The management of the button balance requires very great care, and should never be used except for the precious metals, as the ores, fluxes, &c., must be weighed on a less delicate balance. To adjust and thoroughly understand the reading of the button balance needs instruction, and no one should use one until the working of it has been explained. It may be well, however, to mention that the glass slide should always be kept down except during the weighing operation, and that the apparatus should never be by any means exposed to acid or other deleterious fumes.

A very good plan is to use the conventional assay ton weights in weighing the ore, as, by this conventional system, the number of ounces of precious metal in a ton of ore may be known according to the amount of milligrammes, &c., the button of precious metal weighs.

The assay ton (A.T.) (about 45 grains English) weighs 29,166 grammes, or 29,166 milligrammes.

If 1 A.T. of ore yields a button of 1 milligramme, a ton of ore yields 1 oz. troy of precious metal.

One-tenth A.T. is a very convenient quantity of ore to take; for if the button weighs  $x$  milligrammes, this represents 10  $x$  oz. of precious metal per ton of ore.

In the absence of a proper balance, the following may be of service:—

Procure from a carpenter a very thin strip of pine wood (about one foot or fifteen inches long and one-third of an inch wide). Place a fine needle across by means of wax, or through the middle. Next obtain a piece of sheet tin or other metal (one inch by half-inch), and bend its edges up perpendicularly one-quarter inch on each side. On these upturned portions place the needle ends. Should the beam not balance properly, trim either end by shaving off very small pieces until it does. Now divide the strip into twenty equal parts, *i.e.* ten on each side of the middle, and mark them 1, 2, 3, &c., so that the 1 marks may be nearest the middle and the 10 marks at the ends.

Three weights are required:—

One grain: This can be obtained by weighing out a piece of thin brass wire (ends bent together) on a chemists' balance.

One-tenth grain: To obtain this, place the one-grain weight on the 1 mark of the wooden balance and place such

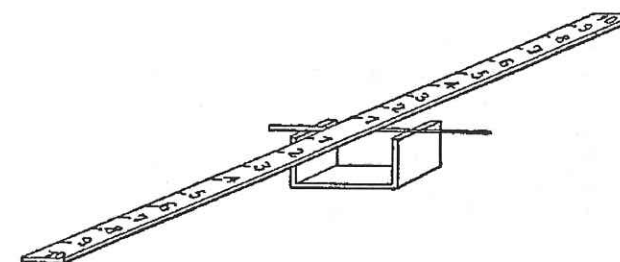


FIG. 42.

a smaller piece of wire, bent at the ends, on the 10 mark on the opposite side, as will cause the beam to balance properly.

One-hundredth grain: To obtain this, place the one-tenth grain weight on the 1 mark, and a piece of thread or such like material on the 10 mark on the other side as will cause the beam to balance properly.

#### To weigh the Button of Gold or Silver.

Place it on the 10 mark and see if 1 grain on 10 mark (opposite side) exactly balances it; if it does, the button weighs 1 grain. If the wire weight be too much, move it towards the middle of the beam to a division, until it is a little lighter than the button. Leave it on this mark. Then take the one-tenth grain, and, commencing from the end of the beam, move it towards the middle until the division reached is that one where this weight together with the first weight is just lighter than the button. Then proceed with the one-hundredth grain in the same way.

Suppose, now, that the one grain weight be at 8, the one-tenth grain at 7, and the one-hundredth at 3, the weight of the button is .873 grains, that is, a little more than eight-



tenths of a grain. A rule of three sum then determines the amount of precious metal per ton of ore.

If a certain weight of ore yields eight-tenths of a grain, how many grains will there be in a ton of similar ore? (N.B. There are 29,166 troy ounces in one ton.) The number of ounces of precious metal in a ton will be known.

#### DRY ASSAY FOR SILVER AND GOLD.

In a gold and silver assay, the precious metals in the sample, either by the scorification or "fusion in a crucible" method, have to be absorbed by lead, and the resulting button of lead containing the gold and silver has to be cupelled in the muffle; the final result being that the precious metals are left on the top of the bone-ash cupel as a shining globule.

As an assaying apparatus or "outfit" is to be obtained complete in a chemical apparatus shop, there is no occasion to enter into too much detail, the portable furnaces manufactured for cupellation in a muffle being made expressly for prospectors and assayers. The most necessary articles are the following:—

An ore and button balance with weights, two or three muffles, Hessian crucibles, scorifiers, cupel mould, crucible, scorification and cupel tongs, pokers and scrapers, an iron pestle and mortar (or a plate and rubber), box sieve (80 mesh), spatula, hammer, bone-ash for making cupels, litharge, borax, carbonate of soda, iron nails, nitre, coke, charcoal, &c., test tubes, acids, brush for cleaning the buttons.

*To light the fire.*—First, place some dry twigs and paper or wood shavings or chips, and above this slightly larger wood round about the outside of the muffle, and set light to it. Then throw in pieces of charcoal, coke, or anthracite coal broken into small pieces about the size of hen's eggs. Shut the mouth of the muffle and the grate door. Raise the temperature as high as possible for the scorification process.

Though fusion in a crucible is very convenient for poor gold and silver ores, inasmuch as a greater charge can be used at once than in a scorifier, the scorification process is, however, the usual one for ordinary ores.

#### Assay of Gold and Silver Ores by Scorification:—

Charge—Finely powdered ore . 50 grains.

\*Granulated lead 500—1000 "

Borax . . . 5 "

Half the lead should be mixed with the powdered ore and placed in the scorifier; the other half should be spread over this, and the borax on the top. The scorifier may then be placed in the muffle and the door closed until fusion is complete. Then the door may be partly opened and the temperature raised until the surface is covered with litharge, the whole time being about half an hour. The scorifier can then be taken out by the tongs and the contents carefully poured out into an iron cup or mould. When cool, the button of lead (which contains the gold and silver) should be detached from the slag, cleaned by hammering, and then, in the shape of a cube, is ready for cupellation.

If Fusion in a Crucible be desirable, the following formulæ are to be recommended:—

For ore, chiefly of rock—

Charge—Ore . . . . 100 to 500 grains.

Red lead . . . . 500 "

Charcoal powder . 20 to 25 "

Carbonate of soda and borax 500 " together.

The more quartz in the ore, the more carbonate of soda should be used; the more iron and other metallic bases, the more borax. The ingredients should be well mixed together and a little borax placed on the top. The crucible should be heated, though not too rapidly at first, until the contents are quite liquid. This will take about twenty minutes. After which it may be removed and the contents

\* Lead used in assaying should always be, in the first instance, cupelled, in order to find out whether it contains any silver mixed with it, which it usually does. The number of parts of granulated lead used varies according to the nature of the ore.

Character of Ore.	Parts test Lead.	Borax.
Quartz.	8	$\frac{1}{4}$ th to 1.
Galena.	6	$\frac{3}{4}$ th.
Arsenical, antimonial, iron or copper pyrites ores.	10—16	$\frac{1}{10}$ th to $\frac{1}{4}$ th.

poured into the iron mould. When cool, the lead button should be detached from the slag, cleaned, and beaten into the shape of a cube; it is then ready for cupellation.

Fusion for silver and gold bearing copper ores and sulphides. Weigh the ore and roast it before fusion is commenced:—

Charge—Ore	.	.	.	100 to 500 grains.
Red lead	.	.	.	1000 "
Charcoal powder	.	.	.	35 "
Carbonate of soda	.	.	.	200 to 3000 "
Borax	.	.	.	150 to 300 "

#### Cupelling.

While the muffle is in the process of heating, place the empty cupel (to make which, see next page) inside, and when the proper temperature of the furnace is reached, known by the cherry-red colour, gently, by means of the cupel-tongs, place the lead button (containing the gold and silver) obtained from the scorification or "fusion in the crucible" method into the concave hollow of the bone-ash cupel. Close the door of the muffle until the temperature of the fused metal is the same as that of the muffle. The behaviour of the assay can be observed through a slit at the side or top of the door. The assay must not be allowed to "freeze" ("freezing" is known by the fumes ascending right to the top of the muffle), nor must it be too hot, (being too hot is known by the fumes scarcely rising at all, and the outline of the cupel being indistinct). If inclined to "freeze," a piece of charcoal may be put into the muffle to increase the heat, and the fire stirred. When the proper temperature is attained, the fumes from the cupel should reach about half-way up the height of the muffle, the cupel should be red, and the metal very luminous, while a stream of fused matter circulates about on the surface of the molten liquid. The button gradually becomes more convex, and at last a mirror-like speck of bright silver or gold, or both, is left. The cupel should then be gradually drawn by means of the cupel tongs to the muffle door, so that the metal may not "spit," which it might do were the cupel to be too suddenly

cooled in the cold air. In form the little button should, if a proper one, be well rounded, crystalline below, and easily detached from the cupel. As the button may contain both silver and gold, it should, after being cleaned by brushing with a paint brush and weighed, be removed and subjected to the action of nitric acid, in order that the silver may be dissolved and the gold left in the form of a dark powder; after this the gold may be weighed, and the original weight of the button, minus the weight of the gold, will represent that of the silver.

N.B.—To separate the two metals in the button, place the button in a test tube with about ten times its weight in nitric acid (dilute), and boil for about a quarter of an hour; the silver will be dissolved and the gold left. The liquid should be decanted, a little pure nitric acid poured on the gold powder to make sure that no silver remains, and the liquid poured off and the gold washed and dried. If the appearance of the button suggests that it is rich in gold, some silver must be fused with it before acid is poured on, as unless there be three times the amount of silver as gold, the "parting," as the above process is called, will be incomplete.

Indications of the presence of metals in the ore known by cupel stains:—

*Antimony*—pale yellow to brownish red scoria; sometimes the cupel cracks.

*Arsenic*—white or pale yellow scoria.

*Cobalt*—dark green scoria and greenish stain.

*Copper*—green or grey, dark red, or brown.

*Iron*—dark red brown.

*Lead*—straw or orange colour.

*Tin*—grey scoria; tin produces "freezing."

*Zinc*—yellow on cupel; the cupel is corroded.

#### To Prepare Bone-ash Cupels.

The ash of burnt bones (that of the sheep or horse is preferable) should, in not too fine nor too coarse a state, be mixed with water (about an ounce of water to a pound of bone-ash), so that it may, when of the proper consistency, adhere together when pressed, although not stick to the

fingers. Place a metal disc—a coin if it fits well—into the bottom of the cupel mould, and then fill the cavity with bone-ash; place the hammer with the convex base on the top of the ash and give it a smart blow by a mallet or other hammer. The cupel can then, by means of the finger, be pushed uppermost and out of the mould.

#### Assay for certain Metals other than Gold or Silver.

To find the amount of lead in Galena, the usual lead ore.

Charge—powdered ore, two or three times the weight of carbonate of soda, three iron nails (tenpenny) placed in the top for taking up the sulphur, and a cover of salt or borax.

The assay may be conducted in a muffle or other furnace.

The crucible—two-thirds full of ore and fluxes—should be heated to redness, and the temperature gradually raised until the operation is finished, which will be in about twenty or twenty-five minutes.

The contents of the crucible are to be poured into a mould, and, when cool, the lead button separated from the slag.

Weight of button

Weight of ore sample  $\times 100 =$  percentage of metal.

As galena always contains more or less silver, the resulting button ought to be assayed for the precious metal in the cupel. As a cupel does not conveniently absorb much more than its own weight of lead, the button may have to be divided into two or more portions, and each of these cupelled separately.

Galena may be roughly assayed for lead by placing the powdered ore, without fluxes, in an iron dish, and exposing it to the heat of a blacksmith's forge.

To assay Copper ores by the crucible method, including the refining process, requires much practice, and for this reason the "wet assay" is the more suitable for obtaining an approximate estimation of the amount of metal in a copper ore.

#### Assay of Tin Ore.

If the ore be poor, it ought to be concentrated, the vein-stuff being got rid of as much as possible. If mixed with iron or copper pyrites, it ought to be calcined or else treated with acids. One method is, as in Cornwall, to mix the ore with one-fifth of its weight of anthracite coal or charcoal, and to expose it in a crucible to a great heat for about twenty minutes. The contents are then poured out into an iron mould, and the slag carefully examined for buttons.

Another method is to mix 100 grains of the ore with six times its weight of cyanide of potassium, and expose the mixture to the heat of a good fire for twenty minutes. The contents are allowed to cool, and afterwards broken to remove the slag. The buttons are then weighed.

To assay Mercury ores, see MERCURY, Chapter V.

#### Antimony.

To determine the amount of antimony in an ore containing sulphide of antimony and more or less vein-stuff:—

Place about 2,000 or more grains of broken-up ore in a crucible, the bottom of which is perforated, and the hole in which is partially closed by a small piece of charcoal. Now fix the bottom of this crucible into the mouth of another crucible, so as to be about half-way down its depth. Then lute\* the lid and also the joint between the two crucibles with fireclay and sand. By placing the lower crucible under the furnace bars and the upper one above, the heat of the furnace will cause the sulphide of antimony, which fuses at a red heat, to collect in the lower crucible, while the quartz and other matter will remain in the upper one. The operation should take about an hour and a half.

When pure, sulphide of antimony contains a little more than 70 per cent. of metal.

#### WET ASSAYS.

##### Gold.

Powder about half an ounce of ore. Add four times its weight in a mixture of 4 parts hydrochloric and 1 part

\* A dough of fresh fireclay and ground firebricks is a good lute.



nitric acid, in an evaporating dish or other apparatus. Evaporate the decanted solution to dryness, hydrochloric acid being added as evaporation proceeds. Add sulphate of iron, dissolved in water, to the gold solution, both being previously warmed. The gold is precipitated as a brown powder. Filter the solution and weigh the dry precipitate.

This method, however, is not to be recommended so much as the dry assay.

#### Silver.

Dissolve the powdered ore in nitric acid, and throw down the chloride of silver precipitate by adding a solution of common salt or else hydrochloric acid.\* If chloride of lead and mercurous chloride are absent, the solution may be decanted or filtered, and the chloride of silver weighed: three-quarters of the weight very nearly represents pure silver. Or else the chloride of silver may be fused and the metallic silver collected and weighed.

#### Lead.

Place the powdered ore in a porcelain dish or other convenient and suitable apparatus, and thoroughly dissolve it in strong nitric acid by heat until the residue is nearly white and red fumes cease to be given off. Add a few drops of sulphuric acid and evaporate to dryness; then add water, and filter. As silica and certain sulphates may be in the residue, boil it along with carbonate of soda for about forty minutes. Filter. Dissolve the residue—carbonate of lead, &c.—in acetic acid. Add a little sulphuric acid to the solution. Filter or decant the solution. The residue—sulphate of lead—nearly represents 68 per cent. of metallic lead.

#### Copper.

The most accurate method of determining the amount of copper in an ore is to thoroughly dissolve the ore in acid, then to add ammonia until a blue colour is obtained,

\* Ammonia added to the precipitate would dissolve the chloride of silver, would blacken the mercurous chloride, and would not alter the chloride of lead.

and then to drop from a graduated burette a standard solution of ferrocyanide of potassium until the solution becomes discoloured.

Number of markings on burette : present reading :: known strength of solution :  $x$  where  $x$  is the number of grains of copper in the weighed portion of the ore.

$$\frac{x}{\text{weight of ore}} \times 100 = \text{percentage of copper in the ore.}$$

The burette method, like the dry assay, requires great care in order to insure accuracy, and might mislead one who has not studied and practised it, as certain metals other than copper may sadly affect the results. On this account there is no occasion for explaining the process in detail, as the prospector will find the following method comparatively simple.

Take finely powdered ore, say 25 grains, drive off sulphur, &c., by roasting (q.v.) in a porcelain dish.

Dissolve by heating in nitric acid. Add a little sulphuric acid and evaporate to dryness. Dilute in water and pour the solution into a basin. If well polished sheet or other iron be placed in it, and left for an hour or so, the metallic copper will form on its surface, and by means of a feather may be rubbed off and weighed.

Or else (to avoid roasting). Moisten the powdered ore in sulphuric acid, and add nitric acid. Let it be thus heated for about an hour or so, and let nitric acid be constantly added during the operation. Add hydrochloric acid to get rid of nitric acid, which may be judged by absence of chlorine smells. Dilute with water and obtain copper on the inserted iron as before. To see that all the copper has been properly deposited, dip the polished point of a knife-blade into the solution; if it has not, a film of copper will be left on the knife.

$$\frac{\text{Weight of copper}}{\text{Weight of ore sample}} \times 100 = \text{percentage of copper in the ore.}$$

#### Iron.

To assay an iron ore by the wet method, the standard solution of bichromate of potash is, by means of a graduated

burette, added to the iron solution (the powdered ore dissolved in hydrochloric acid); but like the other burette assays, this requires so much practice in order to secure reliable results, that there is no occasion to enter into details concerning it. The prospector will rarely require to know the exact amount of iron in an ore, and his own sense will perhaps guide him nearly as well as an assay, as great quantity and good quality are both necessary to make an iron ore payable.

#### Roasting.

In roasting the powdered ore much care is necessary in order that the sulphur, &c., may be expelled. The powdered ore placed in an open and shallow vessel, if possible, should be exposed to a low heat at first, and after a time the temperature may be raised. During the operation free access of air is requisite, and the ore must be constantly stirred by means of an iron wire bent at one end, or other suitable apparatus, so as to prevent clotting. When fumes cease to be given off the operation is finished, about a quarter of an hour being the usual time necessary.

#### Mechanical Assay of Ores.

This is performed by crushing\* the ore and subjecting it to the action of water. If the powdered ore be subjected to the action of water running on an inclined plane or trough with a slope, the heavier particles of metal may be caught up in their descent by means of thin boards (riffles) fastened across the trough. Rough hides, with the hair upwards, may be used to intercept the heavier portions. To "pan" gold, see GOLD, Chap. V.

## CHAPTER X.

### SURVEYING.

To calculate areas.—To find the distance from an inaccessible place.  
—To solve problems in connection with adits, shafts, lodes of a mine.—Position of a shaft with regard to a lode.

In ordinary surveying, a Gunter's chain 66 feet long, and consisting of 100 links, each tenth one of which has some distinguishing mark attached, is very frequently used for measuring lengths. When the number of square links in a piece of ground is known, this divided by 100,000 (the division being performed so easily by striking off five figures from the right hand side to the left) will represent the number of acres in the area.

To find how many acres there are in a rectangular piece of ground, multiply the length in links by the breadth in links, and divide the result by 100,000.

*Example.*—Find the area in acres of a rectangular piece of ground, the length of which is 1,225 links (that is, 12 chains and 25 links), and the breadth 150 links (that is, one chain and a half).

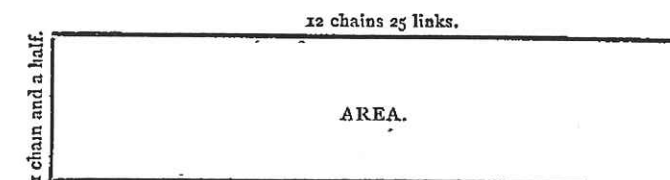


FIG. 43.

$$\begin{aligned} \text{Number of acres} &= \frac{1225 \times 150}{100000} \\ &= 1.83750 \text{ acres.} \end{aligned}$$

H

The number of rods in the .83750 of an acre may be found by multiplying this by 4 and dividing by 100,000; the number of poles, by multiplying the remaining decimal by 40 and dividing by 100,000. Thus:—

$$\begin{array}{r} .83750 \\ \times 4 \\ \hline 3.35000 \\ \times 40 \\ \hline 14.00000 \\ = 3 \text{ rods } 14 \text{ poles.} \end{array}$$

Therefore the whole area = 1 acre, 3 rods, 14 poles.

To find the area of a triangular piece of land, find the area of the triangle in square links and divide by 100,000.

To find the area of a triangle in square links, multiply the length of the base by the length of the perpendicular from the opposite corner to the base and divide the result by 2.

*Example.*—Find the area of the piece of land A B C.

Set up poles at A B C. Measure B C. Travel from B towards C until a point D is reached where the line A D seems to be at right-angles to B C. Measure A D.  
Suppose B C = 1200 links; A D = 161 links.



FIG. 44.

$$\text{Area in acres} = \frac{1200 \times 161}{2} \times \frac{1}{100000}$$

which worked out as in the last example will give  
1 acre, 3 rods, 29 &c. poles.

To find the area of a piece of land indicated by the figure

A D C B. Measure B D. Then find areas of triangles A D B, B D C, as in the last example.

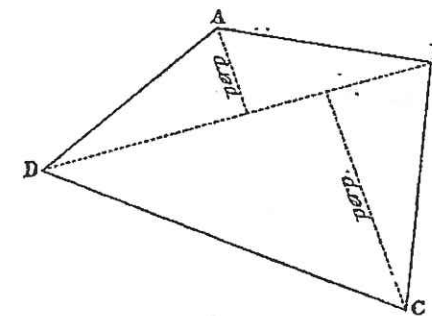


FIG. 45.

The whole area equals the area of the triangle A D B added to that of the triangle B D C.

Similarly, to find the area of a tract of land A B C D E. The whole area equals the area of the triangle C D E, plus that of A C E, plus that of A B C.

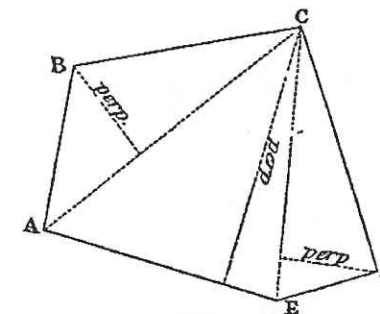


FIG. 46.

In any of the above calculations, should the measurement be by yards and feet, the number of square yards in the land divided by 4,840 will give the number of acres. (See Measures, APPENDIX.)



To find the distance between the points where one is inaccessible from the other—for instance, on the other side of a river.

Required the distance between B and A.

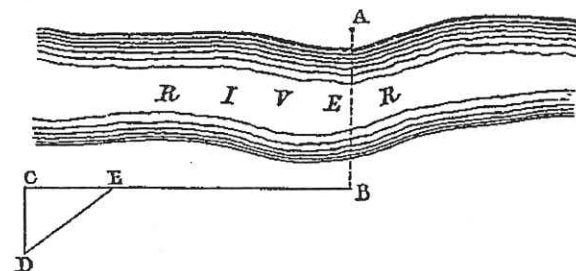


FIG. 47.

Pace off from B, at right angles to the direction B A, a distance B E; then continue pacing off a distance E C, so that E C may be some even fraction of B E (say one-fourth or one-eighth). Proceed, at right angles to C B, along C D until a point D is reached, where D E A seem in one and the same straight line.

Then:—

$$\text{Required length } AB = \frac{CD \times BE}{EC}$$

Very frequently the prospector may wish to form some idea of the length of an adit necessary to meet a perpendicular shaft sunk from a certain known spot, or the length of a vertical shaft necessary to be sunk to meet an adit driven in from a certain point. To solve such problems (as well as many others in connection with surveying) a very limited knowledge of the properties of a right-angled triangle together with a Table of Sines (see Appendix) may prove useful.

Let A B C be a right-angled triangle.

(i.) Perpendicular A B equals length A C multiplied by sin  $\alpha$ .

Let A C represent two points on a hill-side, from which respectively a shaft, A B, is to be sunk, and an adit, C B, driven. Let B be the point where they may be supposed to meet. Measure length A C, and suppose it to be 200 feet.

Measure either the vertical angle  $\alpha$  (which is really  $90^\circ$ —the dip of the hill-side) or else the angle  $c$ , which is the dip.

Let  $\alpha = 50^\circ 30'$ ; and  $c = 39^\circ 30'$ .

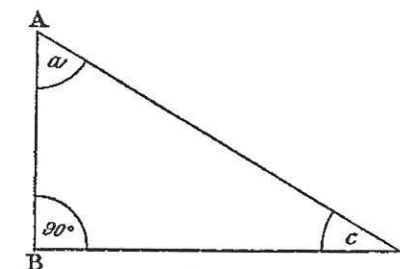


FIG. 48.

Then by (i.)—

Perpendicular A B equals 200 feet  $\times$  sin.  $39^\circ 30'$ .

„ B C „ 200 „  $\times$  sin.  $50^\circ 30'$ .

Now by Table of Sines, sin.  $39^\circ 30'$  is .6361,  
and, sin.  $50^\circ 30'$  is .7716.

Therefore: perp. A B equals 200 feet  $\times$  .6361,  
base B C equals 200 feet  $\times$  .7716.

That is: perp. A B is 127.22 feet,  
base B C is 154.32 feet.

The length of the shaft is 127.22 feet, and that of the adit 154.32 feet.

Should the hill-side A C E G be irregular, such as in Figure 49.

Then A C, C E, E G, should be measured from convenient points, A, C, E, G. To find the length of shaft A O, find the lengths of A B, C D, E F, as in the last example. The whole length A O equals the sum of the lengths A B, C D, E F.

In the same way, the length of the adit O G equals the sum of the lengths B C, D E, F G.

If it is required to know how deep a shaft will have to be sunk, or how long an adit driven, to strike a lode whose inclination to the hill-side is known, certain properties belonging to any triangle and a reference to the Table of

Sines will suffice. Let  $ABC$  be a triangle where  $AC$  represents the hill-side,  $AB$  the lode,  $CB$  an adit. Let the length  $AC$  be known, and also the angles  $a$  and  $c$  (and therefore

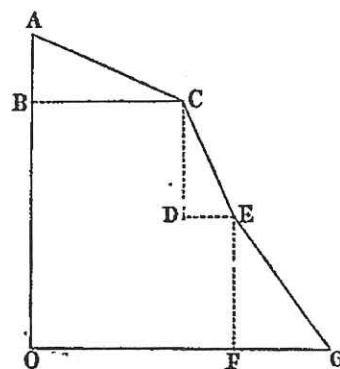


FIG. 49.

the angle  $b$ , which is  $180^\circ$  — the sum of angles  $a$  and  $c$ ). Suppose it be required to know how far the adit will have to be driven to cut the lode and also the depth of the lode.

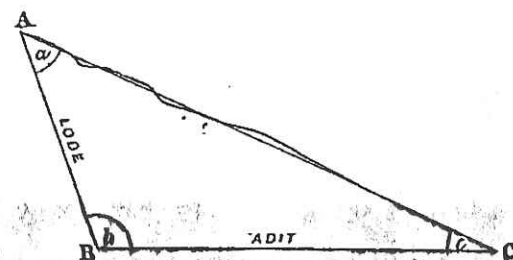


FIG. 50.

By a property of a triangle,

$$\text{Length } BC = \frac{AC \times \sin. a}{\sin. b}$$

$$\text{Also, length } AB = \frac{AC \times \sin. c}{\sin. b}$$

The question, Where ought a shaft to be sunk? has to be decided on as soon as development work is contemplated; and though the question depends in some measure on the nature of the country, rock, and other considerations, the following general hints may be useful.

If the lode dips in the same direction as the hill-side, the shaft ought to be as in Fig. 51, A.

If the lode dips contrary to the slope of the hill, then either the shaft should be sunk on the lode or higher up than the outcrop, or else below the outcrop, so that crosscuts can be driven (Fig. 51, B).

In certain cases, when the lode lies at a considerable inclination from the perpendicular, the shaft should be sunk along the lode rather than in a vertical direction.

Adit levels, which facilitate the proper working of a mine, also help to drain it; and, in consequence, they should be driven at as low a level in the valley as possible, and with a very gentle slope, just sufficient to enable the water to flow away.

With regard to the size of shafts and adits, the dimensions of the former vary from 6 by 5 feet to 8 by 6 feet, while the engine shafts are usually 11, 12, or 13 feet by

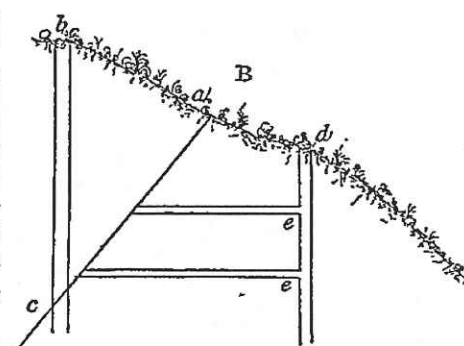
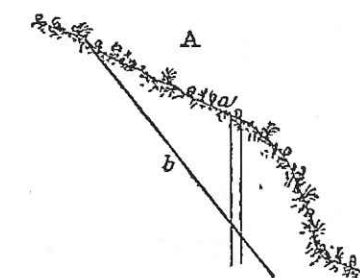


FIG. 51.—A.  $b$ , Lode.  $a$ , Shaft.  
B.  $a$ , Lode.  $b$ ,  $d$ , Perpendicular shafts.  
 $c$ , Where shaft intersects the lode.  $e$ ,  $e$ , Crosscuts.

8 feet; the adits are generally 7 or 6 feet in height, and 4 or 6 feet in width.

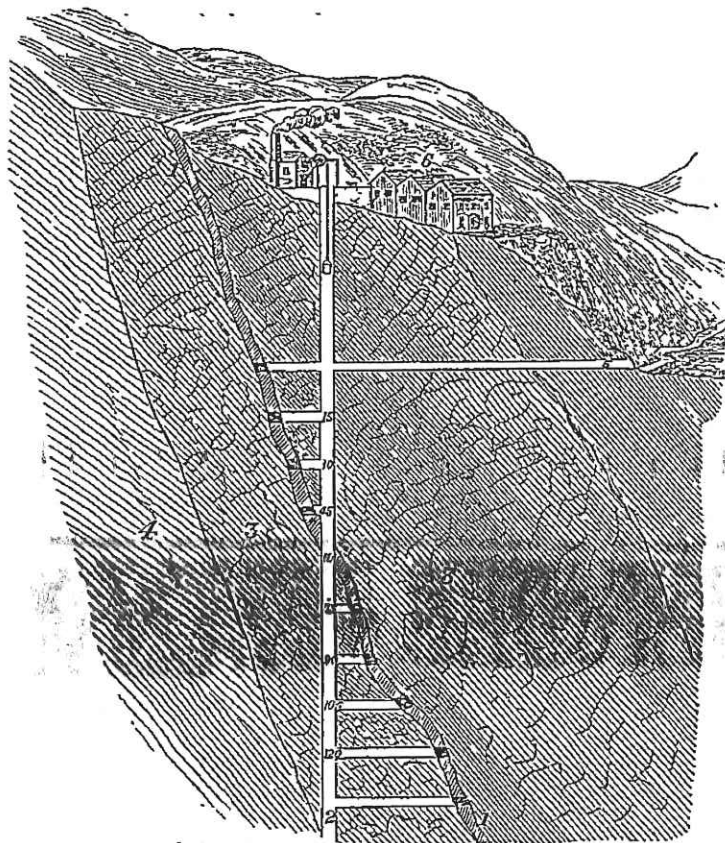


FIG. 52.—LODE WORKED BY VERTICAL SHAFT.

1, Lode. 2, Shaft, 15-120 fathoms crosscuts. 3, Productive strata. 4, Unproductive strata. 5, Adit level. 6, Dressing sheds.

N.B.—The ore is more difficult to raise up a slanting shaft than a perpendicular one.

## APPENDIX.

Weights and measures of England, France, &c.—Weight of various rocks and metallic ores.—Specific gravity of metals, metallic ores and rocks.—Table of natural sines.—Melting point of various metals.—Glossary of terms used in connection with prospecting, mining, mineralogy, assaying, &c.

### WEIGHTS AND MEASURES.

#### ENGLISH.

##### Measures of Length.

3 barleycorns	= 1 inch.
12 inches	= 1 foot.
3 feet	= 1 yard (36 inches).
5½ yards	= 1 rod, pole, or perch (16½ feet).
4 poles or 100 links	= 1 chain (22 yards or 66 feet.)
10 chains	= 1 furlong (220 yards).
8 furlongs	= 1 mile (1760 yards).

A span = 9 inches; a fathom = 6 feet; a league = 3 miles.

##### Surface Measure.

144 square inches	= 1 square foot.
9 square feet	= 1 square yard.
30¼ square yards	= 1 pole, rod, or perch (square).
16 poles (square)	= 1 chain (sq.) or 484 square yards.
40 poles	= 1 rood (sq.) or 1210 square yards.
10 chains	= 1 acre (4840 square yards).
640 acres	= 1 square mile.

##### Solid Measure.

1728 cubic inches	= 1 cubic foot.
27 cubic feet	= 1 cubic yard.



*Measures of Weight.**Troy Measure—*

(by which gold, silver, platinum, and precious stones are weighed, though diamonds are by the carat (150 carats = 480 grains).)

24 grains	= 1 pennyweight.
20 pennyweights	= 1 ounce (480 grains).
12 ounces	= 1 pound (5760 grains).

*Avoirdupois Weight—*

16 drams	= 1 ounce (437½ grains).
16 ounces	= 1 pound (7000 grains).
14 pounds	= 1 stone.
2 stone	= 1 quarter.
4 quarters	= 1 hundredweight (112 lbs.).
20 hundredweight	= 1 ton (2240 lbs.).

A cubic foot of water = nearly 1000 ounces.

## FRENCH.

*Measures of Length.*

Millimetre ( $\frac{1}{1000}$ of a metre)	= .03937 inches.
Centimetre ( $\frac{1}{100}$ " )	= .3937 "
Decimetre ( $\frac{1}{10}$ " )	= 3.937 "
Metre (unit of length)	= 39.3708 ins. or 3.2809 ft.
Decametre (10 metres)	= 32.809 ft. or 10.9363 yds.
Hectometre (100 metres)	= 109.3633 yards.
Kilometre (1000 metres)	= 1093.63 yds. or 6.7138 miles.
Myriametre (10000 metres)	= 6.2138 miles.

*Measures of Surface.*

Centiare ( $\frac{1}{100}$ of an are or sq. metre)	= 1.1960 sq. yds.
Are (unit of surface)	{ = 119.6033 sq. yds. or .0247 acres.
Decare (10 ares)	{ = 1196.033 sq. yds. or .2474 acres.
Hectare (100 ares)	{ = 11960.33 sq. yds. or 2.4736 acres.

*Solid Measure.*

Decistere ( $\frac{1}{10}$ of a stere)	= 3.5317 cubic feet.
Stere (cubic metre)	= 35.3166 " "
Decastere (10 steres)	= 353.1658 " "

*Measures of Weight.*

Milligramme ( $\frac{1}{1000}$ of a gramme)	= .0154 grains.
Centigramme ( $\frac{1}{100}$ " )	= .1544 "
Decigramme ( $\frac{1}{10}$ " )	= 1.544 "
Gramme (unit of weight)	= 15.44 "
Déca gramme (10 grammes)	= 154.4 "
Hectogramme (100 grammes)	= 1544 grs. { 3.2167 oz. Troy or 3.5291 oz. Av.
Kilogramme (1000 grammes)	= 32½ oz. or 2.2057 lbs.
Myriagramme (10000 grammes)	= 22.057 lbs.

The French metrical system is adopted in most countries, including Spain. The following, however, may be of use in countries where Spanish is spoken:—

*Measures of Length.*

12 puntos	= 1 línea (.077 inch).
12 líneas	= 1 pulgada (.927 inch).
6 pulgadas	= 1 sesma (5.564 inch).
2 sesmas	= 1 pie (.9273 feet).
3 pie	= 1 vara (2.782 feet).
4 varas	= 1 estadal (11.126 feet).
The legua	= 8000 vara.

*Measures of Weight.*

12 granos	= 1 tomin (9.2 grains).
3 tomines	= 1 adarme (27.7 grains).
2 adarmes	= 1 ochava or dracma (55.5 grains).
8 ochavas	= 1 onza (.0634 lbs. or 443.8 grains).
8 onzas	= 1 marco (.5072 lb.).
2 marcos	= 1 libra (1.0144 lb.).

## WEIGHT OF VARIOUS ROCKS AND METALLIC ORES.

	Lbs. in 1 Cubic Foot.
Antimony—Sulphide . . . . .	281.25
Basalt . . . . .	182
Chalk . . . . .	125
Clay (ordinary) . . . . .	120
Coal—Anthracite . . . . .	58.25
„ Bituminous . . . . .	53
Cobalt—Tin White . . . . .	400
Copper—Pyrites . . . . .	259.37
„ Grey . . . . .	296.87
„ Red . . . . .	375
„ Malachite . . . . .	250
Flint . . . . .	162
Fluor Spar . . . . .	196.25
Granite—Grey Aberdeen . . . . .	167
„ Red „ . . . . .	165
Gypsum (natural) . . . . .	140
Iron—Pyrites . . . . .	300
„ Magnetic Ore . . . . .	312.5
„ Specular . . . . .	281.2
„ Brown Hæmatite . . . . .	225
Lead—Sulphide (Galena) . . . . .	468.75
„ Carbonate . . . . .	403.75
Limestone—Lias . . . . .	156
„ Magneslan . . . . .	145
„ Compact Mountain . . . . .	170
Manganese—Binoxide . . . . .	300
Marble . . . . .	170
Marl . . . . .	120
Nickel—Glance . . . . .	381.25
Porphyry . . . . .	175—185
Pumicestone . . . . .	57
Quartz . . . . .	166
Sand—River . . . . .	118
„ Fine-grained . . . . .	95
Silver (Horn) . . . . .	287.5
Slate . . . . .	160—181
Syenite . . . . .	164

	Lbs. in 1 Cubic Foot.
Tin—Oxide . . . . .	406.25
„ Sulphide . . . . .	268.75
Zinc—Blende . . . . .	250
„ Calamine . . . . .	268.75

## THE SPECIFIC GRAVITY OF METALS, METALLIC ORES, AND ROCKS.

METALS.	S.G.
Platinum . . . . .	16.0—19.0
Gold . . . . .	15.0—19.5
Mercury . . . . .	13.5
Lead . . . . .	11.35—11.5
Silver . . . . .	10.1—11.1
Copper . . . . .	8.5—8.9
Iron . . . . .	7.3—7.78

## COMMON ORES OFTEN MET WITH IN GOLD AND SILVER BEARING VEINS.

	S.G.
Galena . . . . .	7.2—7.7
Iron Pyrites . . . . .	4.8—5.2
Copper Pyrites . . . . .	4.0—4.3
Zinc Blende . . . . .	3.7—4.2

METALLIC ORES.	S.G.
Silver—Silver Glance . . . . .	7.2—7.4
Ruby Silver (dark) . . . . .	5.7—5.9
„ „ (light) . . . . .	5.5—5.6
Brittle Silver (Sulphide) . . . . .	5.2—6.3
Horn Silver . . . . .	5.5—5.6
Mercury—Cinnabar . . . . .	8.0—8.99
Tin—Tinstone . . . . .	6.4—7.6
Pyrites . . . . .	4.3—4.5
Copper—Red or Ruby Copper . . . . .	5.7—6.15
„ Grey . . . . .	5.5—5.8
Black Oxide . . . . .	5.2—6.3
Horseflesh Ore . . . . .	4.4—5.5
Pyrites . . . . .	4.1—4.3

	S.G.
Copper—Carbonate (Malachite) . . . . .	3.5—4.1
Lead—Sulphide (Galena) . . . . .	7.2—7.7
Carbonate (White Lead Ore) . . . . .	6.4—6.6
Zinc—Calamine . . . . .	4.0—4.5
Blende . . . . .	3.7—4.2
Iron—Hæmatite . . . . .	4.5—5.3
Magnetic Iron Ore . . . . .	4.9—5.9
Brown Iron Ore . . . . .	3.6—4.0
Spathic . . . . .	3.7—3.9
Pyrites (Mundic) . . . . .	4.8—5.2
Antimony—Grey (Sulphide) . . . . .	4.5—4.7
Nickel—Kupfernickel . . . . .	7.3—1.5
Nonneite (New Caledonia) . . . . .	2.27
Cobalt—Tinwhite . . . . .	6.5—7.2
Glancé . . . . .	6.0
Pyrites . . . . .	4.8—5.0
Bloom . . . . .	2.91—2.95
Earthy . . . . .	3.15—3.29
Manganese—Black Oxide . . . . .	4.7—5.0
Wad (Bog Manganese) . . . . .	2.0—4.6
Bismuth—Sulphide . . . . .	6.4—6.6
Oxide . . . . .	4.3

## MINERALS FORMING THE GANGUE OR MATRIX IN VEINS.

	S.G.
Quartz . . . . .	2.5—2.8
Fluor Spar . . . . .	3.0—3.3
Calc Spar . . . . .	2.5—2.8
Barytes . . . . .	4.3—4.8

## ROCKS OF COMMON OCCURRENCE.

	S.G.
Granite } . . . . .	2.4—2.7
Gneiss } . . . . .	
Mica Slate . . . . .	2.6—2.9
Syenite . . . . .	2.7—3.0
Greenstone Trap . . . . .	2.7—3.0
Basalt . . . . .	2.6—3.1
Porphyry . . . . .	2.3—2.7
Talcose Slate . . . . .	2.6—2.8
Clay Slate (Killas) . . . . .	2.5—2.8

	S.G.
Chloritic Slate . . . . .	2.7—2.8
Serpentine . . . . .	2.5—2.7
Limestone and Dolomite . . . . .	2.5—2.9
Sandstone . . . . .	1.9—2.7
Shale . . . . .	2.8

## TABLE OF NATURAL SINES.

	0'	10'	20'	30'	40'	50'
0°	.0000	.0029	.0058	.0087	.0116	.0145
1°	.0175	.0204	.0233	.0262	.0291	.0320
2°	.0349	.0378	.0407	.0436	.0465	.0494
3°	.0523	.0552	.0581	.0610	.0640	.0669
4°	.0698	.0727	.0756	.0785	.0814	.0843
5°	.0872	.0901	.0929	.0958	.0987	.1016
6°	.1045	.1074	.1103	.1132	.1161	.1190
7°	.1219	.1248	.1276	.1305	.1334	.1363
8°	.1392	.1421	.1449	.1478	.1507	.1536
9°	.1564	.1593	.1622	.1650	.1679	.1708
10°	.1736	.1765	.1794	.1822	.1851	.1880
11°	.1908	.1937	.1965	.1994	.2022	.2051
12°	.2079	.2108	.2136	.2164	.2193	.2221
13°	.2250	.2278	.2306	.2334	.2363	.2391
14°	.2419	.2447	.2476	.2504	.2532	.2560
15°	.2588	.2616	.2644	.2672	.2700	.2728
16°	.2756	.2784	.2812	.2840	.2868	.2896
17°	.2924	.2952	.2979	.3007	.3035	.3062
18°	.3090	.3118	.3145	.3173	.3201	.3228
19°	.3256	.3283	.3311	.3338	.3365	.3393
20°	.3420	.3448	.3475	.3502	.3529	.3557
21°	.3584	.3611	.3638	.3665	.3692	.3719
22°	.3746	.3773	.3800	.3827	.3854	.3881
23°	.3907	.3934	.3961	.3987	.4014	.4041
24°	.4067	.4094	.4120	.4147	.4173	.4200
25°	.4226	.4253	.4279	.4305	.4331	.4358
26°	.4384	.4410	.4436	.4462	.4488	.4514
27°	.4540	.4566	.4592	.4617	.4643	.4669
28°	.4695	.4720	.4746	.4772	.4797	.4823
29°	.4848	.4874	.4899	.4924	.4950	.4975
30°	.5000	.5025	.5050	.5075	.5100	.5125
31°	.5150	.5175	.5200	.5225	.5250	.5275
32°	.5299	.5324	.5348	.5373	.5398	.5422
33°	.5446	.5471	.5495	.5519	.5544	.5568
34°	.5592	.5616	.5640	.5664	.5688	.5712
35°	.5736	.5760	.5783	.5807	.5831	.5854
36°	.5878	.5901	.5925	.5948	.5972	.5995
37°	.6018	.6041	.6065	.6088	.6111	.6134
38°	.6157	.6180	.6202	.6225	.6248	.6271
39°	.6293	.6316	.6338	.6361	.6383	.6406

	0'	10'	20'	30'	40'	50'
40°	6428	6450	6472	6494	6517	6539
41°	6561	6583	6604	6626	6648	6670
42°	6691	6713	6734	6756	6777	6799
43°	6820	6841	6862	6884	6905	6926
44°	6947	6967	6988	7009	7030	7050
45°	7071	7092	7112	7133	7153	7173
46°	7193	7214	7234	7254	7274	7294
47°	7314	7333	7353	7373	7392	7412
48°	7431	7451	7470	7490	7509	7528
49°	7547	7566	7585	7604	7623	7642
50°	7660	7679	7698	7716	7735	7753
51°	7771	7790	7808	7826	7844	7862
52°	7880	7898	7916	7934	7951	7969
53°	7986	8004	8021	8039	8056	8073
54°	8090	8107	8124	8141	8158	8175
55°	8192	8208	8225	8241	8258	8274
56°	8290	8307	8323	8339	8355	8371
57°	8387	8403	8418	8434	8450	8465
58°	8480	8496	8511	8526	8542	8557
59°	8572	8587	8601	8616	8631	8646
60°	8660	8675	8689	8704	8718	8732
61°	8746	8760	8774	8788	8802	8816
62°	8829	8843	8857	8870	8884	8897
63°	8910	8923	8936	8949	8962	8975
64°	8988	9001	9013	9026	9038	9051
65°	9063	9075	9088	9100	9112	9124
66°	9135	9147	9159	9171	9182	9194
67°	9205	9216	9228	9239	9250	9261
68°	9272	9283	9293	9304	9315	9325
69°	9336	9346	9356	9367	9377	9387
70°	9397	9407	9417	9426	9436	9446
71°	9455	9465	9474	9483	9492	9502
72°	9511	9520	9528	9537	9546	9555
73°	9563	9572	9580	9588	9596	9605
74°	9613	9621	9628	9636	9644	9652
75°	9659	9667	9674	9681	9689	9696
76°	9703	9710	9717	9724	9730	9737
77°	9744	9750	9757	9763	9769	9775
78°	9781	9787	9793	9799	9805	9811
79°	9816	9822	9827	9833	9838	9843
80°	9848	9853	9858	9863	9868	9872
81°	9877	9881	9886	9890	9894	9899
82°	9903	9907	9911	9914	9918	9922
83°	9925	9929	9932	9936	9939	9942
84°	9945	9948	9951	9954	9957	9959
85°	9962	9964	9967	9969	9971	9974
86°	9976	9978	9980	9981	9983	9985
87°	9986	9988	9989	9990	9992	9993
88°	9994	9995	9996	9997	9997	9998
89°	9998	9999	9999	9999	10000	10000

## MELTING POINT OF VARIOUS METALS.

Antimony . . . . .	1150° Fahrenheit.
Copper . . . . .	1990° "
Gold . . . . .	2000° "
Iron (Cast) . . . . .	2780° "
Lead . . . . .	617° - "
Mercury . . . . .	39° "
Silver . . . . .	1800° "
Tin . . . . .	442° "
Zinc . . . . .	773° "

## USEFUL BOOKS OF REFERENCE.

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## GLOSSARY OF TERMS

USED IN CONNECTION WITH PROSPECTING, MINING,  
MINERALOGY, ASSAYING, ETC.

### A.

- ACICULAR—Needle-shaped.  
ADAMANTINE—Of diamond lustre.  
ADIT—A horizontal entrance to a mine driven from the side of a hill.  
AGATE—Name given to certain siliceous minerals.  
ALKALIES—Potash, soda (and also ammonia and lithia). Alkalies turn vegetable blue, green; and vegetable yellow, reddish brown. Blues reddened by an acid are restored by an alkali. Alkalies neutralize acids and with them form salts. They precipitate hydrates from their salts.  
ALLOY—A mixture of metals by fusion.  
ALLUVIAL DEPOSIT—A deposit formed of matter washed down or otherwise transported by a natural agency from higher ground.  
AMALGAM—A mixture of mercury with another metal, usually gold or silver.  
AMALGAMATION—The process of uniting mercury with gold or silver in an ore.  
AMURANG (Ceylon)—Gold ore.  
AQUAFORTIS—Name formerly applied to nitric acid.  
AQUA REGIA—A mixture of nitric and muriatic acid. One volume of strong nitric to three or four of hydrochloric acid is a good mixture.  
ARENACEOUS—Sandy.  
ARENG (Bohneo)—Auriferous pay dirt.  
ARGENTIFEROUS—Silver-bearing.  
ARGILLACEOUS—Clayey.  
ARRASTRA—An appliance used for ore-reducing. The ore placed on a hard platform is crushed by means of mules dragging round huge stones.  
ARRORA (Spanish)—25 lbs.  
ASBESTOS—The usual mineral of this name is fibrous and of a dull greenish colour, with pearly lustre.  
ASSAY—Process for determining the amount of pure metal in an ore or alloy.  
ATTAL (Cornwall)—The waste of a mine.  
AURIFEROUS—Gold-bearing.

## GLOSSARY.

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AXE STONE—A species of jade. It is a silicate of magnesia and alumina.

### B.

- BACK OF A LODE—That part between the roof of the level and the surface.  
BACK SHIFT—Afternoon shift of miners.  
BAHAR (Malay)—Weight of 4 cwt.  
BANK CLAIM—A mining claim on the bank of a stream.  
BAR—A course of rock, of a different nature to the vein stone, which runs across a lode. A hard ridge of rock crossing a stream is called a bar in Australia, and on the upper side of which gold is likely to be deposited.  
BARROWS—Heaps of waste stuff raised from the mine.  
BASSET—Outcrop of a lode or stratum.  
BATEA—A small, slightly conical dish, generally about 20 inches in diameter and 2½ inches deep, in which gold-bearing soil is washed.  
BATT—Name given to a highly bituminous shale found in the Coal measures.  
BATTERY—In mining, a stamping mill.  
BEATAWAY—A process of working hard ground by means of wedges and sledge hammers.  
BEDE—A kind of pickaxe.  
BED ROCK—The rock underlying an alluvial deposit, and on which at a gold diggings the most payable "dirt" usually rests.  
BELLY—A swelling mass of ore in a lode.  
BETING (Malay)—Quartz matrix carrying gold.  
BENCH (Australia)—A terrace on the side of a river. Auriferous benches are termed reef wash.  
BLACK BAND—A variety of carbonate of iron.  
BLACK CHALK—A variety of clay containing carbon.  
BLACK JACK—Zinc blende.  
BLACK SAND (Australia)—Name given to black iron and other metals usually accompanying gold.  
BLACK TIN—Tin ore ready dressed for smelting.  
BLIND CREEK—A creek, dry, except during wet weather, or after a freshet caused by melting snow or other cause.  
BLIND LODE—One that does not show surface croppings.  
BLOCK CLAIM (Australia)—A square claim whose boundaries are marked out by posts.  
BLOCK REEFS (Australia)—Those with longitudinal contractions.  
BLOCKING OUT (Australia)—Washing gold-bearing matter in square blocks.  
BLOSSOM ROCK—Coloured vein stone detached from an outcrop.  
BLUE ELVAN—Greenstone.  
BLUE JOHN—Fluor spar.  
BONANZA—A large and rich body of ore.  
BONGKAL (Strait Settlements)—A gold weight = 832.84 grains. .20 bongkals = 1 catty.

BORNASCA—An unproductive mine.  
 BOTRYOIDAL—With surface of rounded prominences.  
 BOTTOM—Bed rock.  
 BOULDERS—Loose rounded masses of stone detached from the parent rock.  
 BRANCH—Small string of ore in connection with the main lode.  
 BRECCIA—A rock in which angular fragments are cemented together.  
 BROWNSTONE (Australia)—Decomposed iron pyrites.  
 BROWNSPAR—A kind of dolomite containing, in addition to the carbonates of lime and magnesia, some carbonate of iron.  
 BUCKSTONE—Rock not producing gold.  
 BUNCH—A small rich deposit of ore.

## C.

CACO (Brazil)—A white quartz.  
 CAGE—Elevator for hoisting and lowering the miners, as well as ore, &c., in the mine.  
 CAJON—(Bolivia) = 50 quintals.  
           (Peru) = 60    "  
           (Chili) = 64    "  
       One marco of gold per cajon of ore = 2 oz. 14 dwt. per ton.  
 CALCINE—To drive off volatile matter by exposing the substance to a gentle heat, &c.  
 CALCITE—Carbonate of lime.  
 CANGA (Brazil)—A kind of auriferous glacial rock.  
 CANNY—Lode containing beds of carbonate of lime and fluor spar is called canny.  
 CANON—A deep valley.  
 CAP ROCK—The formation above the ore.  
 CARBONIFEROUS—Containing coal.  
 CASCAJA (South America)—A decomposed schist on which pay-dirt lies.  
 CARAT—Weight, nearly equal to 4 grains, used for diamonds and precious stones. With goldsmiths and assayers the term carat is applied to the proportions of gold in an alloy; 24 carats represent fine gold. Thus 18-carat gold signifies that 18 out of 24 parts are pure gold, the rest some other metal.  
 CARBONATE—Compound formed by union of carbonic acid with a base.  
 CASCAHO (Brazil)—A kind of gravel, auriferous and diamondiferous.  
 CASING—Material between a reef and its walls.  
 CARBURET—A compound of a metal with carbon.  
 CARGA (Spain)—A mule's load = 380 lbs.  
 CATEAR (Spain)—To search for minerals.  
 CAUNTER (Cornwall)—A lode running across a main lode.  
 CELLULAR—Containing cavities.  
 CERRO (Spain)—Rocky hill.  
 CHERT—A mixture of silica and lime hardened.  
 CHLORIDE—Compound of chlorine with an element.

CLAIM—Land staked off by the prospector as his mining property.  
 CLAVO (Mexico)—A rich "pay" chimney, deep but with horizontal limits.  
 CLEAVAGE—The property of separating into layers.  
 COARSE LODGE—One not rich.  
 COLOUR (to show)—An Australian expression when rock or gravel shows traces of gold.  
 COLORADOS (South America)—Red ores (stained by oxide of iron), similar to "gossan."  
 CONGLOMERATE—Rounded stones cemented together to form a rock.  
 CONTACT LODGE—One between two distinct kinds of rock.  
 CONTOUR RACE—A watercourse following the contour of the land.  
 COUNTRY ROCK—The rock on either side of the lode.  
 COSTEAN FITS—Trenches cut at right angles to the strike of the lode.  
 CORD (of timber)—A pile of wood 8 feet long, 4 feet high, and 4 feet broad; contains 128 cubic feet.  
 COURSE OF A LODGE—Its direction.  
 CRADLE (Australia)—A wooden apparatus for washing gold dirt.  
 CREADERO (South America)—Indication of gold.  
 CREEK—A small stream.  
 CREVICING—Collecting gold in the crevices of rock.  
 CRETACEOUS—Chalky.  
 CROPPINGS—Parts of the vein above the surface.  
 CROSS-COURSES—Unmetalliferous veins which usually cross the main lode at right angles.  
 CROSS-CUT—A tunnel or level driven across the lode.  
 CRUCIBLES—Fireproof vessels used in the roasting and melting of ores, &c.  
 CUT—To intersect the lode, usually at right angles.

## D.

DAMP—A term applied to dangerous gas escaping from the mineral formation in a mine.  
 DEADS—Ore that will not pay for working. Waste or rubbish in a mine.  
 DÉBRIS—Disintegrated rock deposit.  
 DECANT—To pour off liquid (from the sediment) out of one vessel to another.  
 DECREPITATE—To crackle and fly to pieces when heated.  
 DENUDATION—Rock laid bare by water or other agency.  
 DEOXIDATION—The removal of oxygen.  
 DEPOSIT—Matter laid or thrown down; for instance, mud or sand which, after suspension in water, has settled down.  
 DESICCATION—The act of drying.  
 DEVELOPMENT—Work done in opening up a mine.  
 DIALLING—Surveying a mine by means of a dial.  
 DILUVIUM—Drift deposit.

**DIORITE**—A trap rock; crystalline, whitish, speckled black, or greenish black.  
**DIP**—The angle which the lode or bed makes with the horizon is called the dip. (*See Chap. II.*)  
**DISTILLATION**—The driving off vapours from a substance, and allowing them to condense on another surface or vessel.  
**DOLERITE**—A kind of basaltic rock.  
**DOLLY** (Australia)—An apparatus used in washing gold-bearing rocks.  
**DOLOMITE**—A mineral composed of the carbonates of lime and magnesia. Magnesian limestone.  
**DRIFT**—A loose alluvial deposit. A level in a mine.  
**DRIVINGS**—Horizontal tunnels in a mine.  
**DRUSE**—A hollow space in veins which are lined with crystals.  
**DRYONE**—A term used in America for calamine (carbonate of zinc).  
**DUCTILE**—That can be drawn out into wire or threads.  
**DUMP**—The place where ore taken from a mine is deposited.  
**DUNES**—Small hills formed of blown sand.  
**DYKE**—Intruded igneous rock which fill up fissures and rents in stratified rocks.

## E

**EARTHY COAL**—Name sometimes applied to lignite or brown coal.  
**ELBOW**—A sharp bend in a lode.  
**ELVANS**—Certain granitic and porphyritic rocks that traverse the granite and slate rocks of Cornwall.  
**EMERY**—Compact form of corundum. Is hard enough to scratch quartz and several gems.  
**EVAPORATE**—To cause to become a vapour.  
**EXEMPTED CLAIM** (Australia)—A mine allowed to remain unworked some time.

## F

**FACE**—The extreme end of tunnel or other mining excavation.  
**FALSE BOTTOM**—In alluvial mining the term is applied to a stratum on which pay dirt lies, but underneath which are other bottoms.  
**FANEGADO** (Spain)—90½ F. = 100 acres.  
**FAST**—Term applied in Cornwall to solid rock immediately beneath the surface drift.  
**FATHOM**—6 feet.  
**FAULT**—Dislocation along a fissure.  
**FEATHER ORE**—A sulphide of lead and antimony.  
**FREDER**—A small vein running into a main lode.  
**FERRUGINOUS**—Iron-containing.  
**FILTER**—To remove the particles of matter in a liquid by pouring it on to some substance, such as filter paper, so that the liquid runs through and leaves a solid residue behind.  
**FISSURE**—A crack or rent in rocks.

**FLATS**—In mining language, decomposed parts of limestone strata which are mineralized. These flats sometimes extend for a long distance horizontally, though they are not very thick.  
**FLEXIBLE**—Capable of being bent without elasticity.  
**FLINT**—A massive impure variety of silica.  
**FLOAT-STONE**—A cellular quartz rock. The honeycomb quartz detached from a lode is often called float-stone by miners.  
**FLOAT GOLD**—Very fine gold dust which floats on running water.  
**FLOATING REEF**—Lumps of gold-bearing rock found in alluvial beds.  
**FLOOR**—When a lode is bent into a flat bed.  
**FLOURED MERCURY**—Mercury which is useless for amalgamation purposes, on account of its having a film on it caused by sulphur, arsenic, or some other substance.  
**FOUR GOLD**—The finest gold dust.  
**FLUKAN**—A vein filled with a soft greasy clay crossing or running in or under a lode.  
**FLUME**—Apparatus (boxing or piping) used for conveying water from higher ground to alluvial gold diggings.  
**FLUX**—A substance used to promote the fusion of metals in the reduction of ore.  
**FOOTWALL**—The underwall of a lode.  
**FOSSIL**—Term applied to express the animal or vegetable remains found in rocks.  
**FOSSICKING**—Same as "Creviceing."  
**FOOTWAY**—Ladders by which miners descend or ascend the shafts of a mine.  
**FRAME**—A sloping board used in the washing of stream tin.  
**FRIABLE**—Easily powdered.  
**FUSE**—In blasting, the fire is conveyed to the blasting agency by means of a prepared tape or cord called the fuse.  
**FUSION**—Making liquid by heating.

## G

**GABBRO** (Italian)—Name given to a particular kind of serpentine rock.  
**GAD**—A steel wedge used in underground mining.  
**GALLERY**—A horizontal excavation in a mine.  
**GAMELLE** (Brazil)—Wooden bowl for "panning out" gold.  
**GANGUE**—The non-metallic rock material in a lode.  
**GLACIER**—A body of ice which descends from the high to the low ground.  
**GONGE** (America)—Soft clay between the ore and the walls of a lode.  
**GOSSAN**—A cindery rock, a mixture of quartz and oxide of iron found on the surface or near the top of a lode.  
**GRANULATED**—In the form of grains.  
**GRANZAS** (Spain)—Poor ores.  
**GRASS ROOTS**—At the surface.  
**GREDE** (Venezuela)—A yellow iron-stained clay.  
**GRIZZLY** (America)—Bars set in a flume to intercept the large stones.

GULCH—A ravine.  
 GULLY—Feeder of a creek.  
 GUNNIE (Cornwall)—3 feet wide.  
 GUTTER—Lowest portion of an alluvial gold deposit.

## H.

HACIENDA (Spain)—House where ore is smelted.  
 HADE—Dip of a lode.  
 HALVANS—Waste of copper ores.  
 HARROW (Australia)—An apparatus used for mixing gold-bearing clays.  
 HALTER (New Zealand)—A miner working on his own account.  
 HANGING WALL—The upper wall of a lode.  
 HANGING SIDE—The under side of a lode.  
 HEADINGS—Coarse gravel above gold-bearing "wash-dirt."  
 HEAD-RACE—An aqueduct for bringing a supply of water.  
 HEAVE—When the lode stops at the end of a level on account of a cross-course, it is said to be "heaved."  
 HEAVY GOLD (Australia)—Gold of the size of gun-shots.  
 HECRADO (Spain)—The dip of a lode.  
 HENNA (Sassaparilla)—Gold.  
 HORN—A hard siliceous rock.  
 HORSE—A term applied to masses of country rock found in a lode.  
 HORSE-FLESH ORE—Purple copper ore.  
 HYDRAULIC HOSE (America)—The hose used to conduct a stream of water, the force of which washes down the face of the alluvial gold-bearing deposit.

## I.

INCH (Miner's) (America)—That amount of water that will flow through a horizontal opening 24 inches long by one wide, the water above standing six inches above the hole. Discharge = 95 cubic feet per hour.  
 INCLINE—A slanting shaft.  
 INCRUSTATION—A coating of matter.  
 IRIDESCENT—Showing rainbow colours.

## J.

JACOTINGA (Brazil)—Iron ores associated with gold.  
 JEWELLER'S SHOP (Australia)—Rich patch of gold-bearing matter.  
 JIGGING—A process of sorting ores by means of an apparatus having a vertical and rotary motion in water.  
 JOINTS—(See Chap. II)  
 JUMPING A CLAIM—Taking possession of an abandoned or unworked mine by force or otherwise.

## K.

KAL—A coarse kind of iron.

KAOLIN—(See Chap. VII.)  
 KILLAS—A name applied in Cornwall to a hard slate or shale through which lodes run.

## L.

LAMINA—A thin slice.  
 LAVADOROS (Spain)—Gold washings.  
 LEAD (Australia)—Well-defined bed of pay dirt.  
 LEADINGS (Australia)—The unprofitable drift above pay dirt.  
 LEDGE—Same as a lode.  
 LENTICULAR—Of an onion shape.  
 LEVEL—Horizontal gallery in a mine.  
 LITHARGE (Protoxide of lead)—Used as a flux by assayers.  
 LITTLE GIANT—A movable nozzle attached to hydraulic hose.  
 LOADSTONE—An iron ore consisting of protoxide and peroxide of iron; is magnetic.  
 LOB OF GOLD (Australia)—Rich gold deposit found in an area of small extent.  
 LOCATE—To establish a right to a mining claim.  
 LODE—A longitudinal fissure or chasm filled with ore-bearing matter and between two walls.  
 LODE PLOT—A horizontal lode.  
 LONG TOM—An apparatus used in the washing of gold-bearing "dirt."  
 LUTE—Pasty matter to close joints of chemical apparatus and to coat surfaces so as to protect them from the action of flame.

## M.

MACIZO (Spain)—The part of a lode unworked.  
 MALLEABLE—Capable of being sliced and hammered out.  
 MAN ENGINE—Machine by which men ascend and descend a mine.  
 MANTO (Spain)—A single layer of a stratum.  
 MARCO (Spain)—Weight = 8 ounces.  
 MATRIX—The mineral associated with ore in a lode. (See Chaps. I. and VII.)  
 MEERSCHAUM—A white soft mineral, dry to the touch, and adhering to the tongue when licked by it. Is a silicate of magnesia. Specific gravity .8 to 1.0 when dry. Occurs in veins or in kidney-shaped nodules in serpentine rocks.  
 METALES CALIDOS (hot metals) (South America)—Minerals capable of amalgamation, such as native silver, hornsilver, &c.  
 METALES FRIOS (cold metals)—Minerals not suitable for the amalgamation process.  
 METALLURGY—Art of extracting metals from their ores, &c.  
 METAMORPHIC—Altered.  
 MOCK ORE—A false kind of mineral.  
 MONTON (Spain)—A pile of ore. In Mexico a monton = 17 quintals.  
 MOUNTAIN BLUE—Blue copper ore.



MOUNTAIN CORK—A variety of asbestos.  
 MOUNTAIN GREEN—Malachite.  
 MOUNTAIN LIMESTONE—Carboniferous limestone.  
 MUESTRAS (Spain)—Samples of ores.  
 MUFFLE—A small oven-shaped fire-proof furnace.  
 MULLOCK (Australia)—Débris of the country rock filling a fissure.  
 MUNDIC—Iron pyrites.  
 MUSCHELCHALK (German)—A limestone formation containing fossil shells.

## O.

OITAVO (Spain)—About the eighth part of an ounce.  
 OJO (Spain)—A bunch of ore.  
 ONCA = 442.72 grains troy.  
 ORE—The mineral matter containing metal.  
 OUTCROP—The parts of the lode or bed exposed at the surface.  
 OXIDE—The combination of a metal with oxygen.  
 OXIDIZING—Combining with oxygen.

## P.

PACOS (South America)—Mixture of ores of silver with oxides of iron, &c. Usually reddish in colour.  
 PAINT GOLD—Gold coating quartz pebbles in cement.  
 PALMA (Spain)—Quarter of a vara or Spanish yard.  
 PAN—To separate gold from other matter by washing it in a basin, is called "panning out." (See GOLD, Chap. V.)  
 PANNIO—The strata through which a lode passes.  
 PARTING—Separating the silver from the gold in the button derived by cupellation. The silver is dissolved by nitric acid, the gold remaining as powder.  
 PAY DIRT—Payable portion of alluvial deposits.  
 PEACH STONE (Cornwall)—A soft greenish rock found in certain lodes. A peachy lode is often a very good one for tin.  
 PEPYRA (Spain)—A gold grain.  
 PETERING—The pinching out of a vein.  
 PICUL (China)—A weight of 133½ lbs.  
 PILE (Australia)—To "make a pile," is to make a lot of money.  
 PIPING—Washing gold deposits by means of a hose.  
 PITCH (Cornwall)—The part of a lode let out to be worked on tribute.  
 PLACER—An auriferous alluvial deposit.  
 PLATA (Spain)—Silver.  
 PLATE—Black shale; a slaty rock.  
 PLATEAU—Flat table land.  
 PLUMBAGO—Graphite or black lead.  
 POLVILLOS (Spain)—Good ores.  
 (Mexico)—Tailings.  
 POCKET—A single deposit of mineral, not a vein.  
 POST—Limestone strata divided horizontally with very thin beds of shale.

PRECIPITATE—Name given to solid matter which is separated from a solution by the addition of reagents or by exposure to heat.  
 PREDRAS DE MANO (Spain)—Good ore specimens.  
 PROSPECTOR—One who searches for metals or valuable minerals.  
 PROSPECTOR'S CLAIM—A piece of ground, larger than an ordinary claim, given to the discoverer of mineral treasures in a country.  
 PUDDLING (Australia and America)—Machine for mixing gold-bearing clays with water.  
 PULGADA (Spain)—An inch.  
 PULVERIZE—To powder.  
 PYRITES—Native mineral composed of a metallic sulphide, arsenide, or both.  
 PUTTY STONES (America)—Soft pieces of decomposed rocks found in alluvial diggings.

## Q.

QUARTZOSE—Rock with a great deal of quartz in it.  
 QUINTAL (Spain)—100 lbs. Spanish, equal to 101½ English lbs.

## R.

RACK—An artificial watercourse.  
 RACKING—Separating ores by means of water on an inclined plane.  
 RAKE—A fissure vein.  
 REAL (Spain)—A mining district.  
 REAGENT—A substance added to determine the presence of some other substance by the mutual action of the one towards the other.  
 REDUCTION—The separation of a metal from its compounds.  
 REEF (Australia)—A lode. Outcrop of strata.  
 REEF WASH—Gold-bearing drift where two underground leads join.  
 REFRACTORY—Resisting great heat and difficult to smelt.  
 RESIDUE—The solid matter remaining after a liquid has been filtered or evaporated.  
 RIBB—Lines of ore in the veins.  
 RIDER—A projecting piece of rock crossing a fissure or mineral vein and thus dividing it.  
 RIDDLE—A large iron sieve for sifting ore.  
 RIFFLES—Strips of wood nailed across and rising above the bottom of a sluice, in order to catch the gold during the process of washing.  
 RISE—Same as "stope." The excavation in the back part of a level.  
 ROASTING—Driving off volatile matter, such as sulphur, arsenic, &c., by gently heating the substance and allowing air to have free access to it during the operation by means of stirring.  
 ROOF—The top side of a lode or bed.  
 ROUGHS—Tinestone with less than 65 to 70 per cent. of oxide of tin.  
 RUN—Course of a vein. Ore is spoken of as running so much metal per ton.

## S.

- SALTING A MINE**—Introducing mineral matter in a mine to deceive purchasers.
- SAMPLE**—Specimens of ore for assaying.
- SCAD (America)**—Uncommon name for a nugget.
- SCALY**—Loose ground.
- SCORIFIER**—A shallow fire-proof vessel used in gold and silver assaying.
- SCRIN**—Smallest kind of vein.
- SEAT**—Bottom of a mine.
- SECONDARY ROCKS**—Those older than the Tertiary and newer than the Primary.
- SECTILE**—Easily cut.
- SEDIMENTARY ROCKS**—Deposit of sand, clay, &c., from water.
- SHAFT**—A vertical or inclined excavation in a mine.
- SHAKES**—Caverns in lead mines.
- SHALE**—A schist imperfectly formed.
- SHELF**—The rock on which drifted matter rests.
- SHEPHERDING (Australia)**—Doing just as little work on a mine as is required by mining law.
- SHIFT**—Time during which men work in a mine.
- SHODING**—Tracing pieces of detached veinstones to the parent lode.
- SICKENED MERCURY**—See "Floured Mercury."
- SILICATE**—Combination of a base with silicic acid.
- SILICEOUS**—Containing silica.
- SINK**—An excavation under a level. To "sink" is to excavate downwards in a mine.
- SLAG**—Vitreous mass which covers the fused metal in the smelting hearths. In ironworks it is called cinder.
- SLICKENSIDES**—Name given to smooth striated surfaces of rocks or of mineral lodes.
- SLIDE**—A fracture of strata, or displacement in a mine.
- SLIME ORE**—Finely crushed ore mixed with water to the consistency of mud or slime.
- SLOVAN**—The "cropping out" of a lode or strata.
- SLUICE**—A box or trough through which gold dirt is washed. (See GOLD, Chap. V.)
- SMALLS**—Small-sized pieces of ore and gangue.
- SPATHIC**—Sparry. Term applied to certain carbonates.
- SPIEGELEISEN**—Variety of highly carbonised pig-iron.
- SPOTTED (America)**—Leads in which the gold is irregularly disseminated.
- STALACTITIC**—Like a stalactite (of the form of a cylinder or cone, as the carbonate of lime incrustations hanging from the roof of limestone caverns. Stalagmites are the columns or cones like these which are on the floor of the caverns).
- STAMP**—A weight used for crushing ore.
- STEATITE**—A mineral, usually of a greenish colour and soapy to the touch, containing much talc. Soapstone.

- STOSES**—In a mine, the stoses are the steps which the ore assumes while being excavated; when the steps are above the miner's head they are "overhead" stoses; when under his feet "under-hand" stoses.
- STRAKE**—An inclined board used in the separation of gold from small quartz.
- STRIKE**—A find; a valuable development made in an unexpected manner.
- STRIKE**—The straight line in which the plane of a bed or lode cuts the plane of the horizon is called the strike. (See Chap. II.)
- STRING**—A thin course of ore.
- STUFF**—Ore associated with the gangue of a lode.
- SUBLIMATE**—The matter formed by condensed vapour when a mineral is heated.
- SUBMETALLIC**—Of imperfect metallic lustre.
- SUBTRANSPARENT**—Of imperfect transparency.
- SULPHATE**—A salt containing sulphuric acid.
- SULPHIDE**—A combination of a metal with sulphur.
- SUMPS**—Pits sunk below the foot of mining shafts for the purpose of draining, or proving a lode.
- SWITCHER**—A crevice branching from a main lode.
- SUN VEIN**—A vein running in a southerly direction.

## T.

- TAILINGS**—The earthy matter left after it has been washed or otherwise worked for metal.
- TAIL RACE**—An aqueduct for conveying away dirty water and tailings.
- TAN (China)**—Weight = 133½ lbs.
- TEARY GROUND**—Ground easily broken up or worked.
- TERTIARY ROCKS**—Those of the most recent formations, and above the Secondary and Primary.
- TINSTONE**—Ore containing small grains of oxide of tin; tin ore.
- TIN STUFF**—Ore obtained from a tin lode.
- TON OF FIREWOOD (Australia)**—Average of 50 cubic feet of wood.
- TRAPPEAN ROCKS**—Certain rocks (such as basalt, &c.), which form in terraces.
- TREND**—The course of a vein.
- TRIBUTE**—When miners work on tribute they pay so much to the owners of the mine and keep the ore stuff as their own property.
- TUCKER GROUND (Australia)**—Poor ground, just rich enough to allow a miner to buy food and the bare necessities of life.
- TUFA**—A kind of limestone rock deposited by water containing carbonate of lime.
- TYE**—The point where two veins cross. Also, an adit.

## U.

- UNDERLIE**—Dip.

## V.

VANNING—Washing "tin stuff" by means of a shovel.  
 VARA (Spain)—Length = 33 inches; the Spanish yard.  
 VEIN STUFF—Ore associated with gangue.  
 VITREOUS—Glassy.  
 VOLATILE—Capable of easily passing off as vapour.  
 VUGGY LODE—A hollow lode.

## -W.

WALLS—The boundaries of a lode; the upper one being the "hanging," the lower the "foot wall."  
 WASH DIRT (America and Australia)—Auriferous gravel, sand, clay, &c.  
 WHIM—An apparatus for drawing the ore of a mine up the shaft.  
 WINZE—A shaft sunk from level to level.

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